THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 33. Thursday, March 4, 1926. No. 498.

PUBLISHED WEEKLY.

Subscription Terms: 15s per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of
THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI, LONDON, W.C.2.

Telephone: 6611 Gerrard (2 lines).
Telegrams: Zacatecas, Westrand, London.

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Forthcoming Events.

MARCH 10.
Institute of Metals:—Annual general meeting in London.
MARCH 11.
Institute of Metals:—Extraordinary general meeting in London, followed by adjourned general meeting.
MARCH 12.
Institute of Metals (Swansea Local Section):—Ordinary meeting at Swansea. Discussion on "Annealing."

Institute of British Foundrymen.

MARCH 9.
Lancashire Branch (Burnley Section):—Ordinary meeting at Burnley. "The Usefulness of Wood Patterns Mounted on Boards," Paper by A. E. Wilson.
MARCH 11.
London Branch:—Ordinary meeting in London. "Comparisons in Foundry Methods and Processes," Paper by E. Longden.
MARCH 13.
Birmingham, Coventry and West Midlands Branch (Junior Section):—Ordinary meeting at Birmingham. "Recent Developments in Cast-iron Production," Paper by J. G. Pearce, B.Sc.
West Riding of Yorkshire Branch:—Ordinary meeting at Keighley. "Sandslingers," Paper by W. H. Baund.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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"Hot Spots."

When the steel manufacturer wishes to ensure a sound ingot he makes use of a "dozzle," a "masselotte," a "fire-brick header," which are synonymous terms basically relating to the differential cooling of the ingot. With some types of steel, especially high carbon, well "killed" material, when cast into ordinary ingot moulds, the phenomenon of "piping" exhibits itself so pronouncedly that it may extend to five-sixths of the length of the ingot. This is overcome, in crucible practice, by inserting in the ingot mould, when it is nearly full, a fireclay "dozzle" previously heated to about 1,000 deg. C., and then filling up with the balance of the liquid steel. In grey-iron foundry practice, of course, feeding heads are of analogous use, except that they are not usually preheated. In the manufacture of larger ingots, quite often the fire-brick header, that is, a large-sized dozzle, is often not preheated, but reliance is placed upon its lower heat-conductivity to cause the metal in contact with it to cool more slowly than when surrounded by the metallic ingot mould, and so create a reservoir for feeding. Before leaving the question of ingot making we wish to emphasise that almost invariably there is a certain amount of segregation in any piped area.

We have been minded to draw attention to the above in order to focus attention on Mr. Wilkinson's interesting Paper printed elsewhere in this issue, wherein he emphasises that where the heat radiations from near-by masses of metal in any one casting intermingle so as to cause the superheating of a portion of sand mould or core, then a "hot spot" results, which causes a cavity in the adjacent metal. Whilst previous workers, notably Smalley, Ronceray, Léonard, Fletcher, Longden and others, have thrown light on this subject, we feel that Mr. Wilkinson has put the case in a nutshell by rightly emphasising the "hot spot."

The reason why we have made rather extended reference to steel-ingot practice is because it represents an intentionally contrived "hot spot," and has been the subject of a considerable quantity of high-grade research. Thus, if foundrymen are agreed that "hot spots" cause "piping," "draws," "pockets," or "cavity" in the adjacent metal, then we would refer them to the researches of Brinell (who varied composition with a view to the elimination of piping and, incidentally, blowholes), Hadfield (who suggested the external heating of ingot tops), Brearley (who worked with stearine ingots), Village, and many others, the bulk of the researches having been presented to the Iron and Steel Institute.

We disagree with Mr. Wilkinson when he says "the denser the mould is rammed the more difficult it will be for the heat to radiate," as we presume that imprisoned air is a better refractory than silica grains. Thus, if the sand is tightly rammed, the grains are in better contact, and are in a better position for radiating. We admit that this is theoretical, derived from experience with steel, and we suggest that some enthusiastic foundryman prove this by inserting an ordinary thermometer half an inch from two mould faces, one of which is well, and the other lightly, rammed. If "hot spots" cause cavity, how would the hot-mould process effect the general results? Would there be sufficient diminution of lag, that is, difference in the critical temperatures reached by the various sections of the mould faces during the metal's freezing range?

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Birth of the Electric Furnace Industry.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—It may be of interest, in view of the discussion now proceeding in your columns, to mention one or two further facts concerning the inception and growth of the electrical furnace industry in this country.

In the year 1905 attention had been aroused to such an extent regarding the possibilities of the electric furnace that Messrs. John Brown & Company, Limited, considered the subject worth investigating, and conjointly with Messrs. Thos. Firth & Sons, Limited, arranged to hire and work a Kjellin induction furnace then operating at Gysinge, Sweden, in order to determine whether the process was applicable to the manufacture of Sheffield high-class steels. To put the matter beyond doubt, the firms mentioned sent their own metallurgists with instructions to run the furnace in accordance with Sheffield methods and ideas, the resulting steel afterwards returned to Sheffield for examination and analyses. This was in October, 1905.

The knowledge thereby gained concerning the quality of steel so produced was sufficiently encouraging to warrant further trials, the upshot being that Messrs. John Brown & Company, Limited, contracted with Mr. Otto Frick, of Stockholm, Sweden, for the supply of an induction furnace which was claimed to be superior in certain respects to the Kjellin furnace of the same type. Preliminaries were through, and erection commenced about the middle of 1906, the furnace being at work towards the end of the same year. This was, as far as we are aware, the first electric furnace in operation in Sheffield.

The Frick furnace was of somewhat larger capacity than the Gysinge furnace, taking about 250 kw. It was used to make all classes of steel. A cupola was arranged to work in conjunction with the furnace, so minimising an objectionable feature of the induction furnace, *i.e.*, the necessity of leaving one-third of the previous charge in the melting space in order to start the next.

Yours, etc.,

JOHN BROWN & COMPANY, LIMITED.

Atlas Steel and Iron Works, Sheffield.

February 25, 1926.

An Interesting Example of Welfare Work.

BY OUR ENGINEERING CORRESPONDENT.

The importance of welfare schemes in connection with the engineering industries does not require much emphasis, and an interesting example of the mutual benefits reaped by both employers and employees are the methods in vogue at the works of Messrs. Glenfield & Kennedy, Limited, of Kilmarnock, Scotland. As is well known, their establishment includes extensive foundries, whose normal consumption is 400 tons of pig-iron and 20 tons of brass a week, in addition to gunmetal, phosphor bronze, and other alloys, and they have gradually built up a most comprehensive welfare system, every part of which is self-supporting and independent, controlled by the members themselves. The firm have altogether about 2,000 employees, and in the first place food is obtained at cost prices from the canteen, the dining-hall being used in the evening as part of the premises for a social club. There is also included a complete range of sporting and athletic clubs for badminton, gymnastics, football, cycling, swimming, photography and bowls, all run in the same way by the members, while another feature is a summer holiday camp. Education has, of course, always been a prominent feature in Scotland, and this section of the work naturally receives great prominence, the many subjects taught including hygiene, "safety first," engineering workshop practice, and the use of the slide rule, many of the classes being held in conjunction with the Ayrshire Educational Authorities. A unique feature, also, is a flourishing horticultural association, having a membership of over 400, one of the first in Great Britain in connection with engineering works, while the works ambulance corps numbers 34 qualified men, all entirely voluntary.

Again there is a works holiday bank, established in 1919, with over 1,000 members, while the foremen have a separate club of their own.

Finally, it may be stated that Messrs. Glenfield & Kennedy, Limited, have always adopted the principle of well-lighted and well-warmed shops, the bad conditions in this respect obtaining in many foundries being, as is well known, largely responsible for the difficulties in the way of obtaining boys to take up foundry work.

The London Convention.

In connection with the forthcoming Convention of the Institute of British Foundrymen, to be held from June 15 to June 19 in London, the following subscriptions have been received to date. Altogether it is hoped to raise £1,000, and further subscriptions should be sent to the Convention Secretary, Mr. H. G. Sommerfeld, Charterhouse Chambers, Charterhouse Square, London, E.C.1. These will be acknowledged through the Press by means of additional lists.

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Empire Mining and Metallurgical Congress, 1927.

The Empire Council of Mining and Metallurgical Institutions (Cleveland House, 225, City Road, London, E.C.1) on behalf of the ten constituent bodies have accepted the invitation of the Canadian Institute of Mining and Metallurgy to hold the Second Empire Mining and Metallurgical Congress in Canada in August-September, 1927. Further particulars will be announced later.

THE PHILADELPHIA FOUNDRYMEN'S ASSOCIATION has addressed a letter to the United Gas Improvement Company urging their co-operation for the financing and working of a blast-furnace plant, in order that local foundry owners may be independent of the distant pig-iron producers and eliminate the present annual importation of 400,000 tons of foreign iron.

Recurring Foundry Problems.*

By D. Wilkinson, A.I.Brit.F.

The art of founding has been described as making a hole in sand and filling it with molten metal. For brevity, this definition has much to commend it; and if its accuracy were commensurate with its brevity, the title of this Paper would never have arisen.

The object of the founder is to produce a metal article of a predetermined shape which shall be of a uniform composition and solidity. His difficulties and problems arise from the high temperatures at which he has to manipulate the metal he uses. In preparing the metal, transferring it to the mould, and cooling it to the normal temperature, many conditions arise which militate against uniformity of composition and solidity: and to control these conditions adequately requires a care and forethought that can only be realised by daily contact with them.

It may be well to commence by defining the qualities required in the castings produced. It is desired to produce castings which shall be uniform in composition and solidity. By a casting of uniform solidity is meant one which is definitely free from internal voids. To define uniform composition is not quite so easy. It can hardly be said that every part of a casting shall consist of the same material, since cast iron is made up of constituents which vary widely in their composition and properties. So it may be said that every part of the casting should consist of the same proportions of the various constituents which make up the cast iron in use.

It is quite safe to say that with the present foundry and metallurgical knowledge it is not possible to take a pattern, and from it to produce one hundred castings which shall be identical in every respect. If anyone thinks differently, let him try the experiment, and at the end he will be a wiser man. The conditions of success are so elusive that, despite the closest control, variations will slip in. Not all the variations that occur destroy the utility of a casting; but we are all too well acquainted with undesired results that prevent a casting fulfilling the purpose for which it was made.

When variations arising from carelessness or from want of skill arise the remedy is obvious and needs no discussion. But when defects of this class are completely eliminated, there remains an irregular proportion of variations which constitute a problem taxing the highest skill and knowledge. The present Paper is a contribution to the study of this problem.

It will be noticed the word variation is used rather than defect. The reason for this is that any departure from a complete uniformity is to be avoided as far as possible. The aim of the founder should be to secure a product which can be relied upon to function in an entirely satisfactory manner. It should not be considered sufficient to produce a casting which is just sufficiently good for its purpose. It is desirable to produce castings which will function, not up to their own limiting strength, but up to the limiting strength of the material from which they are made. As foundry craftsmanship, metallurgical knowledge and designing ability develop, so will the reliability of castings increase, and foundrymen must always keep before them the ideal of reproducing in their work all the best qualities of the material they use. Only along this line can real advance be made.

As it is an open question where foundry troubles, and the resulting problems, really commence, we will begin by considering the pouring of the metal into the mould. It is not proposed to take account of evils arising from the entrainment of air, carrying of slag into the casting, or the partial breaking of the mould by the weight of the iron, as these things can readily be prevented. But when good iron is properly cast into a sound mould, actions and reactions occur which are not yet fully under the control of the founder.

* A Paper read before the Birmingham and Coventry and West Midland Branch of the Institute of British Foundrymen. Mr. A. Harley presiding.

Typical Reactions.

In a green sand mould there is always a certain amount of surface erosion due to the heat and motion of the molten iron. If the mould is carefully made, the amount of material abraded as a fine dust may be small, but it will certainly be present. As the surface of the mould is dried by the molten metal, the generated steam is decomposed by the iron, forming hydrogen gas and magnetic oxide of iron.

$$4H_2O + 3Fe = Fe_3O_4 + 4H_2.$$

The gas burns at the joints and vents of the mould, but the oxide remains behind in the metal. As the oxide is carried up by the iron there is the possibility of further reaction between it and silicon and carbide of iron, forming in the one case silica or ferrous silicate and in the other carbon dioxide, or probably a mixture of oxides of carbon.

$$Si_2 + Fe_3O_4 = SiO_2 + 3Fe.$$

The reaction will most probably go further and ferrous silicate will be formed:—

$$2Si_2 + 3Fe_3O_4 = 4FeSiO_3 + 5Fe.$$

Occasionally, ferrous silicate formed in this manner may be mistaken for slag carried by the metal from the ladle.

In a small mould these reactions may be so limited that they can be ignored with safety: but their effect in a medium or heavy casting may be attended with serious results. As these lighter bodies float on the rising surface of the iron they agglomerate into large masses which, by design or by good fortune, may be carried into the risers: or they may adhere to the side of the mould, or be caught under a core or a projection of the mould, or come to rest in some eddy of the liquid metal and be covered and remain hidden as the mould fills.

Flat upper surfaces of heavy castings frequently show traces of this scum or scoria. Irregularities in the skin of the upper surface are seen; and if these parts are machined, patches of so-called "dirt" are revealed, which even when they are not directly harmful, detract from the appearance of the casting.

Troubles from Scum Inclusions.

Most foundrymen are able to recall some large and expensive casting which, when taken from the mould, appeared to be perfect; so much so that it was a pleasure to look over it: but which upon machining was found to contain in some unexpected place a patch or mass of scoria which completely ruined it. In the writer's opinion quite a number of defects which have been ascribed to liquid contraction or to gas action, would be found, upon careful examination, to be due to this cause.

There is no difficulty in observing the formation of this scoria or scum. Most open sand castings will provide very good examples. In engineering establishments use is frequently made of bars of cast iron of various diameters. The writer has regularly been called upon to supply these articles in all diameters up to eight or ten inches. The larger sizes are usually cast in green sand, with a bottom runner, cut tangentially. The riser used is about 75 per cent. of the diameter of the bar and about 25 per cent. of its depth. Invariably, as these bars are cast, a mass of scum may be seen to form in the centre of the whirling metal, finally coming up the riser right out of the casting. It would be cheaper to make these bars with an open top and pour the metal directly into them: and when this is done, a bar may frequently be made which shows no trace of scum on its surface. But metal cut from these bars sometimes has expensive machining operations done upon it: and it is the writer's experience that a bar cast with a bottom tangential runner, and a riser that will allow the scum to be floated right

out of the casting, yields an article which gives greater satisfaction to the machinist and reduces trouble to a minimum.

To remove these scoria-forming materials from the casting, or to prevent their agglomeration into masses of serious dimensions is sometimes very difficult. As in the bars just instanced, it may be possible by a definite arrangement of runners and risers to lift or wash out of the casting either the whole or a portion of the scoria. Or, again, it may be possible to arrange the gates so that the scoria may be broken up and its collection into dangerous masses or places prevented.

But it is hardly possible, in a casting of more than a small size, entirely to prevent its formation. As a last resort it may be necessary to dry the mould to minimise the trouble; as in a well-blacked and thoroughly-dried mould the abrasion of the mould by the metal, and the reactions between the metal and steam and its products will be reduced to a minimum.

When the mould is filled with metal, other agencies begin their work. Again, all defects arising from irregular ramming, imperfect venting, or over-damp sand, are omitted, as these are easily preventible, and should not occur.

Blow-hole Defects.

On machining the upper surface of a casting one sometimes finds a number of small rounded holes which are quite smooth and which seem to have resulted from bubbles of gas in the metal. Frequently traces of scoria are intermingled with these bubble-holes. Badly-melted, oxidised metal is a prolific source of this trouble; but cases frequently occur in which this explanation does not satisfy a thoughtful founder, anxious to arrive at a correct understanding of the cause of the defect. When a number of castings are poured from one ladle, and some are found to contain this defect while others are free from it, to look for the cause in the cupola practice does not seem quite the proper action to take.

Sulphur is frequently selected as the culprit; but this explanation can hardly be considered satisfactory. Well-made malleable castings may contain up to 0.4 per cent. of sulphur and yet be quite sound and free from this defect; so it is difficult to see how, say, 0.15 per cent. sulphur should cause it when 0.4 per cent. does not. Moreover, no reaction between ferrous or manganese sulpides and the usual constituents of molten iron can be conceived which will liberate a gas as one of its products.

Entrained-air may be one of the causes. If the runner bush is allowed to empty itself when the mould is nearly filled, it is quite possible the injector action of the metal falling down the partially uncovered gate may draw in a quantity of air, some of which will be retained unless the metal is fluid enough to allow it to escape.

But there is no doubt in the writer's mind that the reaction between the oxide of iron formed during casting and carbide of iron present is the usual cause of this trouble. It is difficult to see how this reaction and consequent liberation of gas can be avoided in any casting of medium weight which takes more than a few seconds to pour. The gases burning at the vents is complete evidence of the formation of oxide in the casting; and the secondary reducing reaction can hardly be prevented. It is safe to assume that when the mould is filled with metal, any further oxide formed will remain in contact with the mould and will not enter into the casting. Oxide already in the metal, if reduced by carbide of iron will liberate oxides of carbon, which will rise through the molten metal. Provided the metal is hot enough to prevent the immediate formation of a skin where it lies against the top of the mould, these gases will escape and all will be well. But if the metal happens to be cool, a skin may form before the reaction is completed, and then the gases will be retained immediately under the surface of the casting to be exposed on machining.

Importance of Magnetic Oxide Reaction.

It is on account of the formation within the mould of magnetic oxide of iron (Fe_3O_4) and its subsequent reduction, partially by carbide of iron with the liberation of oxides of carbon, that the foundry axiom of pouring hot to secure a clean casting has arisen. With hot metal, the secondary reaction is completed before the skin of the casting is frozen against the mould and so the gas bubbles escape. Also, with a highly heated iron, although more oxide may be initially formed, its reduction will be more complete; and its complete removal and the escape of the resulting gases yields a sounder casting.

It will be noticed that the defects arising from these reactions are similar to the defects arising from metal oxidised during melting. This metal will contain ferrous oxide, FeO; and its reaction with carbide of iron will yield gaseous oxides of carbon exactly as the Fe_3O_4 does. But the two causes are quite distinct; and it is certainly unwise not to differentiate between the causes, even if the results are identical.

After the mould has been successfully filled with clean, hot iron, some of the more recondite foundry troubles begin. It is not an easy matter correctly to visualise the behaviour of cast iron during solidification. Considering the variety of castings made in the average foundry, the variables introduced into the problem of solidification approach infinity. But certain broad principles are recognisable, and if these can be grasped and the variables grouped around them, the problem will be simplified.

Solidification Voids.

Interesting though the subject is, it is not proposed in this Paper to deal with the metallography of cooling cast iron, but space will be occupied in considering the foundry, rather than the laboratory, aspect of the matter. The formation of voids in the metal during solidification, is the chief concern.

Internal voids, or cavities, which are not due to mould or core disturbances, are usually called "draws" by most founders, and are considered due to contraction. A distinction is frequently drawn between liquid and solid contraction. While it is convenient to assume this distinction, it does not indicate a difference. The action is the same; but in the one case it concerns molten, and in the other frozen metal. Of recent years the action of occluded and dissolved gases in the formation of internal cavities has been studied; and much evidence of the action of these gases has been adduced. The opinion seems to be gaining ground that they are responsible for most, if not all, the internal cavities not due to cores or moulds.

It has for some time been the writer's opinion that the effect of occluded and dissolved gases in cast iron has been considerably over-rated. If, in properly melted metal, occluded and dissolved gases can give rise to serious defects, it would appear impossible to make sound castings from cupola metal. It is sometimes said that perfectly sound castings do not exist; but the writer cannot agree to this. Castings are made in large numbers which are so thin in section, so extensively machined and so carefully tested, that it is impossible any internal unsoundness should escape detection. It is not claimed that 100 per cent. of the castings made are perfectly sound; but it is definitely stated that the machining, testing, and inspection to which many types of castings are subjected, is so extensive and severe, that those which survive and go into service can be guaranteed free from internal unsoundness.

If, then, it is possible to produce castings free from internal unsoundness, the action of gases in properly melted cast iron must either be negligible or very easily controlled. Which of these alternatives is correct?

Occluded Gas Unimportant.

Occluded gases as a direct cause of cavities may be dismissed. An occluded gas is one which is dissolved by a metal on melting and retained on solidification. If the definition is correct, this part of the question settles itself. The metal contains the gases when molten; but it also contains them when solid. They may be extracted from the cold metal in considerable volume by suitable treatment; but they are not liberated by solidification.

A metal, however, may hold gases in solution while molten and eject them upon cooling. If a small piece of silver is melted, withdrawn from

the furnace and allowed to cool in air, as the surface solidifies the gases dissolved in the metal will break through the skin, carrying a portion of the still liquid interior with them. Usually this ejected metal adheres to the button of silver; but sometimes the evolution of gas is so violent that a portion of silver will be thrown some little distance.

Nothing like this ever occurs during the solidification of good cast iron when poured into a good mould. The writer has fed, and watched the feeding, of so many castings that he can categorically state that well-melted cast iron does not normally eject gases upon solidification. If there is any gas ebullition from a feeder, a riser or a runner, it can invariably be traced to cause other than the metal.

An easy experiment will prove this, if proof be needed. Let a clean, thoroughly-heated shank be taken, filled with molten iron and set down to cool. The closest observation will not perceive any liberation of gas during the whole time of freezing.

The cavity-forming action of gases initially present in the iron is secondary, not primary; and if the primary actions are prevented secondary gas action cannot occur. The action of occluded gases is not negligible, but is easily controlled. The primary cause of cooling voids is inefficient feeding during contraction.

Solidification Action Analysed.

Consider the solidification of two plain castings: one an open sand plate, 2 ft. sq. and 1 in. thick, and the other a block 2 ft. cube. It is common knowledge that the plate will contract much more than the cube. The reason for the reduced contraction in the cube is also common knowledge. Assuming the larger casting loses heat uniformly, there will be a time in its solidification when a skin some inches in thickness will enclose a still liquid interior. This liquid interior will evidently exert a tremendous opposition to the contraction of the skin, and this opposition will be reinforced by the expansion which occurs as the metal steadily freezes. The opposition of these forces having prevented the normal contraction of the skin of the casting, it is evident that as the liquid interior freezes and is reduced in volume the skin will not be able to follow it up, and so a void or voids will inevitably occur. As these voids form out of contact with the atmosphere, a vacuum would exist in them were it not that occluded gases are liberated under the influence of heat and reduced pressure. So that as the voids form they are filled with gases liberated from occlusion in the solidified skin or solution in the liquid interior.

It has been assumed that the cube of iron measuring 2 ft. each way has been cooling uniformly on each surface, but it is known that in a casting of this size cooling cannot be uniform. The plate, 1 in. thick, will be still liquid in the middle when the corners and edges are frozen, and when these have cooled to a black heat the middle will still retain its redness. There will be a somewhat similar want of uniformity in the cooling of the cube. The edges and corners will cool more rapidly than the sides, and owing to the upward flow of heat the top will cool more slowly than the sides. If the mould is filled with uniformly heated metal—that is, so filled that no "hot spots" are formed, and no riser is provided—one will inevitably find a large depression on the upper surface sloping down to an internal cavity. The contraction voids will have been partly filled up by molten metal from the middle of the top surface.

If the metal is poured through a single large side-runner, still without providing a riser, the resulting cavity will take a different form. The passage of the whole of the metal over one part of the mould will superheat that part, and this superheat, added to the actual heat of the metal in the heavy runner, will form a "hot spot" that will take part in the feeding of the contraction void. It may probably be found that the top of the casting is flat and apparently solid; but there will be an internal cavity directly communicating with the gate. The contraction void will have been partially filled up with metal from the "hot spot."

In each case it is probable that during the formation and partial feeding of the voids reduced pressures will have liberated gases from the metal, and these gases may have left traces of their passages out of the casting. But the point to be borne in mind is that it is not the gases that have made the void, but the void that has liberated the gases.

Again, if the casting is poured in such a manner that the formation of a "hot spot" is prevented, it is provided with an efficient feeding head, and the contraction is followed up with an adequate supply of hot metal. If this is done no argument is needed to prove that a sound casting, free from contraction voids, will be secured. Moreover, during the whole period of solidification, there will not have occurred the slightest evidence of gas ejectment from the metal. The difference in texture between the middle and the outside of castings of this nature is not concerned with the formation of cooling voids, but with grain growth and graphite formation.

Hot Spots.

The term "hot spot" has been mentioned as bearing upon the question of solidity. By a "hot spot" is meant a part of a casting which does not cool at the same rate as the adjoining parts. This retarded cooling may be due to several causes. Where a large quantity of metal flows over one place, as in a single gate on a large casting, the heating of the sand may retard the cooling of the metal and form a hot spot. By dividing up the gate, or by locating it on a thin part of the casting, the extra heat given up to the sand can usually be dissipated before the casting solidifies. Frequently, especially in castings of medium weight and varying section, hot spots are found to develop not so much by the flow of metal as by obstructed radiation during solidification.

Before putting a pattern into work it is a good thing to consider how the flow of metal in the mould will affect its cooling and which parts are likely to retain the heat longest, since these parts will give most trouble. The drawing of isothermal lines will greatly assist in settling the relative speeds of solidification, but the accurate drawing of these lines on any but the simplest forms of casting is a matter of some little difficulty. It is much easier to draw radiation lines. These lines will show with certainty the relative speed of solidification, and much information can often be obtained from them.

Take the end elevation of an ordinary angle plate (Fig. 1) as an easy example, and draw short lines at right angles to its surfaces. Wherever these lines are open cooling will be rapid. Where

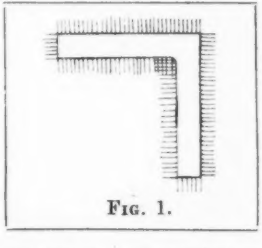


FIG. 1.

they cross, cooling will be retarded and the metal will remain liquid for a longer period than in the other parts of the casting. It will be noticed they cross at the re-entrant angle on the underside of the angle plate, and here, retarded cooling will form a hot spot as the casting solidifies. These lines may be considered to represent the paths along which heat will be radiated from the casting.

Drawing radiation lines of this character and from them locating hot spots not due to gate action, has provided for the writer an adequate explanation of a type of drawhole for which, for a long time, he could not satisfactorily account. In small- and medium-sized castings of irregular shape one sometimes finds drawholes running upward into the heavier parts. The point in question was why a drawhole should form against the force of gravity. It is easy to understand that metal may feed downwards from a hot spot, or riser, into a contraction void, but it is not so

easy to understand why a drawhole should form upwards into the casting. The angle-plate just mentioned will sometimes provide cavities of this nature in the re-entrant angle.

The question arose with the writer during the early days of his apprenticeship. A considerable number of castings weighing about 10 lbs. each were on order, and the trial castings all contained a drawhole on the lower side of a flange. The part of the casting affected is shown in the sketches (Fig. 2). The defect was easily removed by increasing the fillets in the angles and altering the shape and location of the gate. But the question why the void should form against gravity

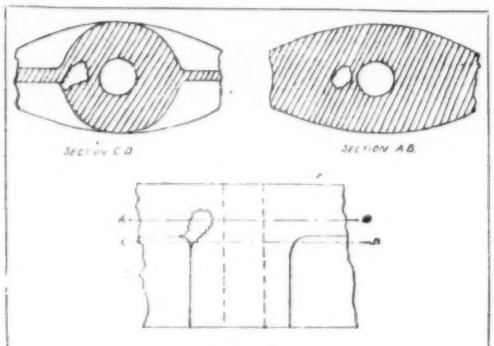


Fig. 2.

remained, and occasionally cropped up again with other castings, and it was some years before an explanation was arrived at that satisfied every point.

The defect under consideration could not be due to a badly-vented core, since it did not communicate with the cored hole; and many other instances were noted in castings which were not cored. Blowing from the mould did not satisfy the objection that the hole was evidently formed when the casting was on the point of complete solidification, as otherwise it would have gone right through to the top. If the hole was formed by mould gases when the casting was almost solid, what had become of the metal which originally filled the hole? That defects of this character are formed while the metal is freezing is proved by the presence of dendrites, or fir-tree crystallites, which can usually be found in their interior.

Diagnosis by Isothermal Lines.

While studying the cooling of masses of metal it occurred to the writer to draw heat radiation lines from the surfaces of the masses being studied, to assist in drawing isothermal lines of correct contour. Afterwards applying these lines to a casting in which a drawhole similar to the one under discussion had occurred, showed that three sets of radiation lines met in the angle. Evidently there would be considerable interference with the radiation of heat during cooling, and a hot spot would be formed as the metal began to solidify. A little further thought provided a solution which completely satisfied every objection. The metal in the casting under examination, as was also the case in the casting shown in Fig. 2, was a common phosphoric iron with a rather lengthy freezing range. Without doubt, a contraction void had formed in the top flange near the hot spot, and into the vacuum thus made occluded gases had been liberated. The high temperature at which these gases existed had given them considerable pressure, and they were able to force their way downward through the semi-molten metal in the hot spot, driving the still molten portion behind them into the void, where it solidified, while they escaped into the mould. In this way a "draw hole" is formed against the force of gravity.

In defects of this character it is not a case of mould gases blowing into the metal, but of occluded gases, liberated into a contraction void, blowing through the semi-molten metal of a hot spot into the mould.

Hot spots formed by retarded cooling during solidification are sometimes partly responsible for a very different form of defect. An example will assist us in forming an opinion. The sectional sketch of a monobloc shows a fault which it is thought is not entirely unknown to makers of these castings.

A sectional casting (Fig. 3) containing this fault was here exhibited. The defect which varies in extent in different castings occurs about half-way down the barrel near the junction of the water jacket. At times it is revealed as a distinct hole after machining. Occasionally it forms a slightly porous place which leaks under water test. Sometimes the casting may pass the water test without a trace of a leak, but examination under a strong light shows a small discoloured patch on the machined surface. The sectioned casting did not leak when water-tested, but the discoloration was visible when it was examined under an electric light.

It is the writer's experience that this defect, however slight it may be, always leads to the immediate rejection of the casting, and the inspec-

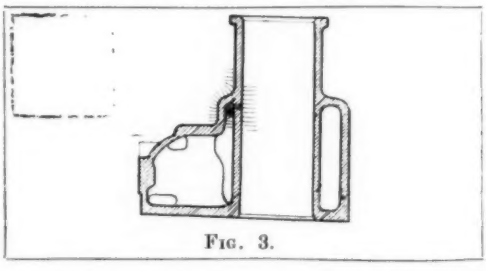


Fig. 3.

tion staff seems to be very well acquainted with the place at which it occurs.

The defect has been ascribed to blowing from the core, due to imperfect venting. It has also been ascribed to segregation resulting from the increased section at the junction of the jacket and barrel. These explanations never satisfied the writer, as they did not account for the fact that when the defect was slight it always occurred below the thickest part of the junction and immediately below the top of the jacket. It would appear that if the defect were due to segregation it should be located in the thicker section instead of below it. If due to blowing from the core, again it would appear the defect should show in the thicker section, or even in the jacket itself.

Segregation as Cause Discounted.

Once more the drawing of radiation lines led the way to a solution which satisfied the objections to previous reasons. Examination of the radiation lines shows that in the upper thin part of the jacket core they converge and cross to an extent that indicates the formation of a hot spot as the casting solidifies. It will also be seen that this hot spot will be located, not where the jacket joins the barrel, but immediately below it, exactly where the defect occurs. Evidently there is a connection between the defect and the hot spot.

Granting the existence of a hot spot, where the metal will remain semi-liquid for a few moments after the adjoining parts have solidified, why should it be defective? A careful examination brings the conviction that segregation is not the cause. Even when the defect is so slight that no leak will occur, the action of gas can hardly be doubted; and when the defect is large enough to show up clearly, the passage of gas is obvious. Why should the core—which is an oil-sand one—give off gas into the metal when the temperature had fallen so much that the greater part of the casting had solidified, if it did not do this while all the metal was molten and at a higher temperature? It is quite evident the defect did not form until the jacket and its junction with the barrel were solid, as these parts are quite sound: and had they been still liquid the gas would have passed into them.

The main vent of the jacket core passes within about 1¼ in. of this defect; and as the main vent in a core of this description is usually made as large as possible, it is not entirely a question of venting. It can be seen that it is rather difficult thoroughly to evaporate and oxidise the binder in the thicker sections of the core without burning the thinner sections; and if the oxidation is not complete, in every part, the heating up of the core by the metal on casting

will give rise to an excessive internal gas pressure as the oxidation of the binder is completed. It will also be seen the pressure will not be greatest immediately on casting, but will increase as the heat penetrates into the thicker sections where the binder is still partially unoxidised. As the casting solidifies, the ferrostatic pressure on the hot spot will be reduced; and if the pressure at this point falls below the pressure of gas in the body of the core, then gases, in addition to passing out of the vent, will also pass into the part of the metal which is still liquid.

This, the writer considers, is the explanation of the defect under consideration; and it suggests its own remedy; a thorough oxidation of the binder used in the core.

A hot spot, we may safely conclude, is always a potential source of trouble; and so should be carefully watched. It is not always easy to locate these points and to prevent them giving rise to defects, but a few general principles may assist in minimising their effects.

The gate should be located as far away as possible from any place where retarded radiation can occur. Gas pressures should always be prevented in these places. The grade of sand and the ramming of the mould should be carefully watched; remembering that the denser the mould the more difficult it will be for heat to radiate.

Chills Suggested as Remedy.

An alteration to the contour of the pattern, where possible, will often remove the difficulty; not merely covering it, but curing it completely. Thorough venting frequently provides a remedy. In this case the venting serves a double purpose. Not only does it relieve gas pressure, but it provides an easier path along which heat can radiate. Take the case of the angle plate mentioned above. (Fig. 1.) If a slot could be made through the bottom of the mould to within a quarter of an inch of the re-entrant angle, it is evident the cooling of this part would be hastened considerably. In a minor degree, venting on to a hot spot acts in the same way as a slot. Failing other measures, a chill, or densener, will provide an effective remedy.

Needless to say no claim is made that foundry problems have been dealt with in an exhaustive manner. The subject is already vast in extent; and as research opens up new fields it continually extends. But it was considered better to confine the scope of the Paper and handle a few of the problems at some little length rather than discursively touch upon many. Foundry practice is filled with problems of the deepest interest; and when the worrying side of these problems can be overcome, thought expended on their solution is abundantly repaid by the satisfaction that accrues from a consciousness of work well done.

DISCUSSION.

Mr. F. H. Hurren, referring to cooling, asked Mr. Wilkinson if he had ever had a similar experience to the following. "You cast," said Mr. Hurren, "say a dozen or eighteen castings of a particular pattern on a day. They are all machine-moulded, the cores, as far as one can tell are made by similar methods, the coring-up is similar so far as humanly possible, the temperature of the metal which is poured into the mould is the same, and yet one is porous and the others are all sound. The porosity is not in the ordinary nature of a draw; it is simply a patch of black and spongy metal which will not stand up to the water test."

Mr. J. V. Murray thanked Mr. Wilkinson for his practical Paper, and said that although he did not quite agree with some of his conclusions a strong case had been made out which might prove to be correct. Mr. Wilkinson had gone a long way towards proving the connection between the defect and the hot spot. It was his (the speaker's) opinion that as the metal froze it pushed certain impurities towards the centre. Although Mr. Wilkinson ruled out segregation there was no doubt it was occurring between the crystals.

The Chairman said the Paper illustrated the fact that foundrymen nowadays had to exercise very minute observation of defects and scientific theories had to be found to account for them. The more numerous such papers were, and the more information was available, the more certain they were to arrive at the real cause of defects. If the constitution of cast iron were simplified they would avoid most of the troubles in cooling down, as well as contraction difficulties and draws. When they considered the structure of cast iron and its many constituents, all with different melting points, it was easy to understand why they experienced so many difficulties with castings. With regard to phosphorus it was the pretty general practice to keep the phosphorus very low. By keeping down the phosphorus in cylinders they practically eliminated all troubles from draws occurring through inequalities of section.

Mr. Wilkinson, in replying upon the discussion, said he would be the last man in the world to say that sand did not cause defects, because he knew to his sorrow that it did. But in the case mentioned in the Paper he did not think it was. It was not the case of the gas flowing up to the spot exactly, because the pressure was even throughout the whole body except in the immediate vicinity of the vents. He was glad to know that on the whole his hearers thought the theories he had advanced were tenable.

On the motion of Mr. Hurren, seconded by the Chairman, a hearty vote of thanks was accorded to Mr. Wilkinson.

Mr. D. H. Wood, in proposing a vote of thanks to the Chairman for presiding, expressed regret that there were not more Birmingham members present and also that Coventry was not better represented. He called attention to the dinner at Birmingham on March 13, when he hoped there would be a strong contingent of Coventry members.

Mr. Lane seconded the motion, which was endorsed by the meeting.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Standardising Foundry Equipment.

To the Editor of The Foundry Trade Journal.

Sir,—Relative to your very able editorial in which you comment upon the excellent Paper given by Mr. M. J. Cooper, I consider you have missed the most important advantage of standardisation, viz., the increased efficiency which would accrue as a result of any moulder being *able* to use any tool.

In my business as a merchant of foundry machinery I have come across many boxes, rammers and similar articles in everyday use which were so clumsily made as to be a *definite* handicap to production; Mr. Cooper has given considerable thought to his subject, and makes many excellent suggestions in regard to most of the plant in general use, but if I had again to earn my living as a moulder, I should hate his rammers!

There *is* room for standardisation of nearly all the articles mentioned by Mr. Cooper, and without doubt very great benefits would accrue if many of his suggestions were adopted—but, again, I hope I may never have to use his rammers.

Yours, etc.,

A. Hammond.

"Boxted," Slough.

[Mr. Hammond has also missed the essential point, that the sketches were all put forward in a tentative spirit. This criticism is destructive, and we suggest that Mr. Hammond might usefully supply a sketch of a rammer that he considers to be a basis upon which the foundry world might usefully standardise.—Editor.]

The Royal Agricultural Society of England has now issued the prize sheet for live stock, poultry, produce, implements, etc., at the Show of the Society to be held at Reading, from Tuesday, July 6 to Saturday, July 10. The total value of the prizes offered (inclusive of champion prizes, special prizes, and medals) is £15,214 16s., of which £1,696 are contributions from the Reading Local Committee, £3,425 16s. from various Breed Societies, and £1,740 from other sources.

The Cupola Furnace.

By J. E. Hurst.

In an article on the cupola furnace, written for the attention of foundrymen, it is hardly necessary to define such a furnace. Naturally all foundrymen are familiar with their cupolas and are deeply interested in their design and economy. The cupola may be regarded essentially as a shaft furnace, and as such is probably the oldest method of melting iron. Shaft furnaces date back to the dawn of metallurgical history. By virtue of its simplicity and low capital costs the cupola retains its position as the premier method of melting cast iron for foundry purposes. From an economical point of view the cupola is the cheapest form of melting cast iron in spite of the admittedly high heat losses due to the partially incomplete and indirect nature of the combustion of the fuel. The intimate contact of the material to be melted with the hot incandescent fuel and the effectiveness of the heat transference to the material to be melted in the cupola offsets the losses due to indirect combustion. This is undoubtedly the reason for the high financial efficiency of the cupola .

The Combustion of Coke.

When air is supplied to incandescent coke combustion takes place, the carbon in the coke being oxidised to carbon dioxide (CO_2), in which process heat is liberated. The reaction takes place under favourable conditions in accordance with the equation $C + 2O = CO_2$, and evolves 14,500 B.T.U.'s of heat for the combustion of every pound of carbon.

When air is passed through a column of heated carbon, combustion does not take place completely in this manner, but a certain amount of carbon monoxide (CO) is formed, due to a secondary reaction between the carbon dioxide and the heated carbon. This reaction takes place in accordance with the equation $CO_2 + C = 2CO$. The combustion of carbon in this manner is very considerably less in thermal value than direct combustion, as is indicated by the figures given below:—

(*a*) The direct combustion of C to CO_2 evolves 14,500 B.T.U.'s per lb. of C.

(*b*) The direct combustion of C to CO evolves 4,350 B.T.U.'s per lb. of C.

(*c*) The direct combustion of CO to CO_2 evolves 4,350 B.T.U.'s per lb. of CO.

The reaction $CO_2 + C \underset{\leftarrow}{\rightarrow} 2CO$ is a reversible reaction and has been studied by Boudouard, Schenck, Le Chatelier and others. The percentage of CO and CO_2 which can exist in contact with carbon under equilibrium conditions at various temperatures and at atmospheric pressure is indicated in the diagram Fig. 1. Even these equilibrium values vary very considerably with the form of the carbon. Graphite does not give the same results as wood charcoal or sugar charcoal.[1] Koppers[2] has shown that the same remarks apply to different varieties of coke, and the amount of CO formed varies very considerably with the character of the coke, other conditions having been maintained constant. The soft, easily burnt varieties of coke produce considerably more carbon monoxide than the hard, less easily burnt varieties.

The completeness or otherwise of this secondary reaction is also profoundly influenced by catalytic agents. Iron itself acts as a very powerful catalyst in this instance. Other conditions enter into consideration in determining the completeness of such reversible reactions, such as the physical character of the reacting bodies, the velocity of the reactions and the time available for their completion.

The conditions of combustion of coke in the cupola are probably very far removed from the equilibrium conditions. The rapid passage of the gases alone through the column of coke in the cupola stack, constantly changing the gaseous atmosphere at any one point, in itself must prevent the attainment of anything like equilibrium conditions. The value of the work under equilibrium conditions is to demonstrate in so far as ordinary cupola conditions are concerned that the combustion of the coke must inevitably be accompanied by the formation of some carbon monoxide.

The problem, therefore, in obtaining economical combustion in the cupola is to maintain the conditions in every respect, such that the minimum amount of carbon monoxide is formed. Quite a large number of factors both of design and operation of the cupola influence these conditions, and these will be discussed as they arise.

Thermal Balance Sheet.

Of the several attempts to draw up the thermal balance sheet of the cupola, probably the most complete one was published in the American *Foundry* some years ago. Whilst in many respects the conditions under which the data for this balance sheet were obtained cannot be considered to represent the best modern practice, the balance sheet serves to give some idea of the relative magnitude of the various sources of the dissipation of the heat arising from the combustion of the coke.

The furnace used was an experimental one 22 in. diam. and 78.8 in. high. The observations were made over a run of a duration of 67 minutes, starting from the commencement of blowing. During this period 2,400 lbs. of iron were melted, the temperature of which was measured at 3,452 deg. F. (1,800 deg. C.). The temperature of the gases issuing from above the surface of the burden at the commencement of the "blow" was 311 deg. F. (155 deg. C.) and 2,333 deg. F. (1,280 deg. C.). The analysis of the gases issuing from the cupola was:—CO_2, 1.2; CO, 9; O, 2.4, and N, 87.4 per cent.

These figures in themselves are somewhat remarkable in that an excess of air and a low value of carbon dioxide are simultaneously indicated. The loss of silicon in melting the charge was 0.25 per cent., and of total carbon was 0.66 per cent. The silicon loss is quite normal, but the total carbon loss indicates oxidising conditions of melting.

A summary of the balance sheet is given under the various headings below:—

Thermal Balance Sheet.

	B.T.U's.	Percentage of total.
1. Heat used to melt and superheat iron to 3,452 deg. F. ..	1,538,000	27.5
2. Heat required to raise temp. of furnace lining	745,000	13.34
3. Heat required to decompose the limestone	102,750	1.84
4. Heat required to form molten slag	260,500	4.66
5. Heat retained in unburnt coke	91,340	1.63
6. Sensible heat lost in the blast	1,343,000	24.15
7. Latent heat lost in the blast	1,422,000	25.40
8. Heat lost by radiation from furnace casing	3,200	0.18
Total heat accounted for ..	5,505,790	98.70
Heat unaccounted for	89,110	1.30
Total heat supplied to furnace	5,595,000	100.00

The calorific value of the coke used was 12,780 B.T.U.'s per lb. The amount of coke used in melting 2,400 lbs. of iron was 528 lbs., less 117 lbs. recovered from the "dump." This is equivalent to a coke to iron ratio of 1 to 6. Admittedly this ratio is not as good as the practice in a good many cupolas, but it certainly represents the conditions obtaining in many cupolas.

The data for this balance sheet have been acquired from a short run of approximately one hour's duration, inclusive of the initial early melting stages. A balance sheet constructed from data obtained over a longer period would be more in accordance with actual practice.

[1] Schenck. Chimie Physique. Paris. 1911.
[2] Koppers. Chem. and Met. Engineering.

The two principal items in considering this balance sheet are No. 6 and No. 7, the sensible and latent heat carried away respectively by the escaping gases. The sensible heat is that contained in the escaping gases by virtue of which they are maintained at the observed temperature of exit. The latent heat is that heat which would be acquired from the escaping gases if the carbon monoxide which the gases contain were completely burned to carbon dioxide.

Only 27.5 per cent. of the gross total heat value available from all sources in this particular cupola is consumed in actually melting and superheating the iron. This figure is in accordance with figures given by various investigators, who place the proportion of the gross total heat absorbed in melting iron in the cupola at round about 30 per cent. The losses are inevitable to a certain extent, and it still remains necessary to determine the minimum value to which these can be reduced to obtain the best possible economic conditions. It is not surprising that many devices and designs of cupolas have been tried with the object of reducing and eliminating these losses, and some of the more important will be referred to. It will finally be seen that the only correct and exhaustive method of comparing the efficiencies of various devices and designs of cupolas is to draw up such thermal balance sheets for the various conditions.

The Cupola Melting Zone.

When air is injected into a column of incandescent coke at predetermined level the coke commences to burn. The extent of the combustion will depend upon the amounts of the participating constituents, namely, the air and the coke, other conditions being constant. Under a given set of conditions a zone of combustion will be rapidly established. It can be imagined that in a column of coke of a cylindrical form as exists in the cupola, that if air at a uniform quantity and velocity is supplied to all points across the section of the column at the same time, and that the coke is uniform in size, shape and area exposed, that the combustion would take place uniformly. Under these conditions the combustion zone would be expected to be a parallel section across the cylinder of a height depending upon the amount of air supplied. Such uniform conditions do not obtain in practice. The air injected at the outside surface of the cylindrical column does not penetrate evenly to the centre of the mass, and combustion does not take place evenly across the section. The tendency of the combustion to be at a maximum round the outside surface of the cylindrical column is a thoroughly well-known and easily observed fact, and, roughly, the upper surface of the combustion zone must take the form of an inverted cone, as at Fig. 2.

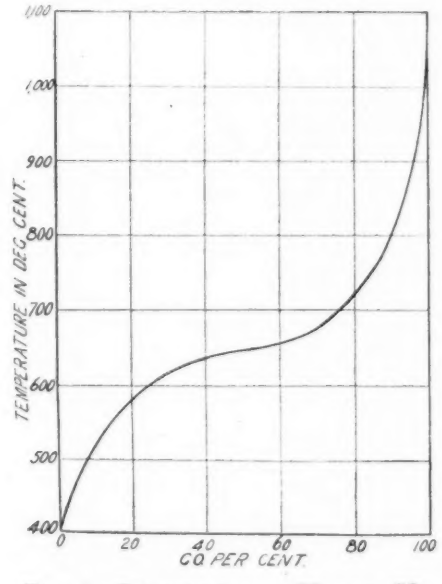


FIG. 1.—PERCENTAGES OF CO AND CO_2 WHICH CAN EXIST IN CONTACT WITH CARBON AT INCREASING TEMPERATURES.

By traversing the cross-section of the coke columns at different levels and taking gas samples at these various points in a cupola operating under normal conditions, the form of the melting zone has been plotted.[3] The cupola used was lined to 27 in. diam. at the tuyere level. Air at 1,000 cub. ft. per minute and 5.3 ozs. pressure was used. The presence of free oxygen in the gases taken at any one point was taken as indication of complete combustion, and the smooth curve, Fig. 2, was drawn through the points at which samples were obtained free from oxygen. The curve drawn through the maximum CO_2 percentages, in the absence of free oxygen, may be taken as representing the upper limit of the melting zone. This is also included in Fig. 2. In actual practice the bed coke is charged into the cupola to a predetermined height above the tuyeres to provide for this melting zone. The level of the upper surface of the coke thus charged is approximately horizontal, and the upper surface of the curved shape as above is formed after the cupola has been in operation for sufficient time until steady conditions of combustion have been established. The height of the bed above the tuyere level necessary for the formation of the most effective melting zone can only be ascertained by trial. The practical rule for ascertaining the correct height is to ascertain the time between putting the blast on and the time at which the first drops of molten metal

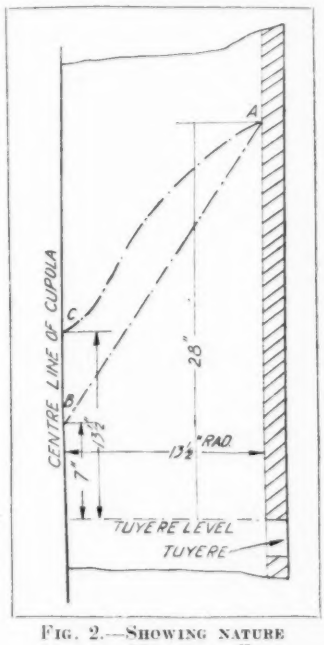


FIG. 2.—SHOWING NATURE OF MELTING ZONE IN CUPOLA PRACTICE.

appears at the tuyere level. This time should be from ten to twelve minutes.

Rawlinson[4] gives the height of the melting zone as 18 to 20 in. above the top tuyeres at the outside edge and on a level with the top tuyeres at the centre. The height of the horizontal surface of the bed initially charged under these conditions would be 8 in. to 10 in. above the top tuyeres. These figures will vary very considerably in larger diameter cupolas.

The observation of the burnt-out portion of the cupola wall after melting locates and fixes the height of the melting zone. This should not be greater than 12 in. in width above the top tuyere level. It is good practice in ascertaining the correct height of the bed coke to start too high and gradually reduce until correct conditions are obtained.

Too high a bed leads to excessive coke consumption and too low a bed to cold metal, oxidation and the presence of solid metal in front of the tuyeres. The depth of the bed below the tuyeres depends

[3] Bulletin Bureau of Mines, U.S.A., No. 54.
[4] "J.I.B.F." 1919.

entirely on considerations of the well capacity of the cupola.

Escaping Gas Analyses.

As in the case of other furnaces, it would be expected that the temperature and composition of the gases escaping from the mouth of the cupola would be invaluable information in determining the efficiency of the operation of the cupola. For a variety of reasons the escaping gas analyses are only of limited utility in cupola practice.

The composition of the gases escaping from the cupola vary according to the position across the section of the cupola. In the Bureau of Mines investigations referred to above a series of analyses of the escaping gases were given at (1) the centre of the cupola; (2) halfway between the centre and the outside edge; (3) at the outside edge. The results are tabulated in Table I.

Table I.—*Composition of Escaping Cupola Gases.*

Position.	1.	2.	3.
	Per cent.	Per cent.	Per cent.
Carbon dioxide CO_2..	8.5	10.2	14.5
Carbon monoxide CO	20.6	17.8	8.4
Free oxygen	0.0	0.0	0.0

These results show at once how important it is to define the position relative to the outside edge of the charge from which the samples are taken. The partial combustion of the carbon monoxide gases from above the surface of the charge is familiar to all cupola operators, and for this reason gas samples taken from above the surface of the charge are valueless.

The variation in the height of the charge throughout the daily "blow" is responsible for a variation in the composition of the gases evolved. This is particularly the case in the last stages of the "blow" when the cupola stack is rapidly emptying itself. A complete series of analyses taken from a day's operation of a cupola by the writer are given in Table II. The escaping gases were sampled at a point 6 in. removed from the outside edge of the charge.

Table II.—*Composition of Escaping Gases in a 36-in. Cupola.*

Particulars.	CO_2 Per cent.	CO. Per cent.	O Per cent.	N Per cent.
Sample taken from slag hole immediately blast put on	14.9	4.7	1.4	79.0
Sample taken from bottom tuyeres 1 hour after start	2.2	11.0	6.2	80.6
Sample taken from top tuyeres 1 hour after start	7.8	6.0	1.4	84.8
Escaping gases sampled every half hour throughout the day's "blow" 1.	13.4	6.2	—	—
2.	17.2	6.6	—	—
3.	14.3	7.1	—	—
Blast pressure 25 water gauge .. .. 4.	16.5	6.7	—	—
Diam. of cupola 36 ins. 5.	11.3	9.1	—	—
Coke ratio .. 1 : 9.5 6.	5.2	10.8	—	—

The gradual increase in CO content of the escaping gases samples 5 and 6 during the "blowing down" stages of the operation are clearly indicated. Koppers considers that the CO content of the escaping gases should not exceed 5 per cent. This value could only be expected close to the side walls of the cupola, and considering the variation in CO content occasioned by the position from which the sample is taken, the above results may be considered typical of good practice.

The gas samples taken at the tuyere levels are of interest in showing the fuller combustion at the higher level of the top tuyeres, and also the combustion of the CO passing in a downward direction through the bed coke and out by way of the slag hole.

The temperature of the escaping gases may be expected to vary very considerably with the height of the charge. It is considered that in a full-size cupola with a full charge that this temperature should not exceed 300 deg. C. In the blowing down stages this temperature will be considerably higher, and the same will apply to the escaping gases from short length cupolas of the type generally described as emergency cupolas. Rhead considers that the escaping gases should be at a temperature of from 300 to 350 deg. C., and that there is little probability of getting below 250 deg. C. escaping gas temperature.

Improved Cupolas.

Many suggestions have been made and a variety of cupolas designed with the object of utilising both the sensible and the latent heat carried away by the escaping gases. These suggestions involve the use of the gases in waste heat boilers, core stoves, mould drying and similar purposes. For the most part these suggestions fail for two reasons, viz., the intermittent nature of the cupola operation and the increased complexity of the design due to the introduction of closed tops and methods of leading away the escaping gases.

The use of the waste heat for preheating the blast and the introduction of subsidiary air with the object of burning the CO gases inside the cupola are the two most serious suggestions which have been considered. The latter suggestion, due to Greiner and Erpps, was attempted by means of either successive hours of small bore tuyeres arranged horizontally or spirally up the sides of the cupola above the main tuyere level. It was expected that such an arrangement would supply air in small doses at the higher levels which would successfully burn the carbon monoxide without raising the temperature so high as to bring about further reduction of the carbon dioxide thus formed. The author had considerable experience

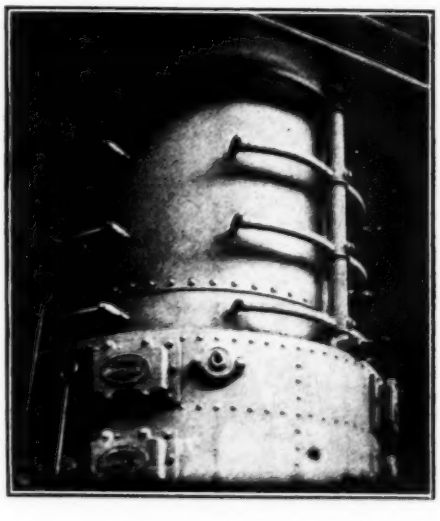


Fig. 3.—Showing Experimental Subsidiary Tuyeres.

of this type of furnace some years ago, and it was found that the above expectations did not materialise, and the method was finally abandoned. The carbon monoxide was certainly burnt at the higher levels, and at the same time the temperature was raised so high that the reduction of the carbon dioxide was accomplished again at still higher levels. There was very little economy of coke and the melting rate and temperature of the metal was lower than without the auxiliary tuyeres. The arrangement used by the writer is illustrated in Fig. 3.

The use of preheated blast has been suggested, and a variety of ways of carrying this out have been proposed. The use of the waste gases for this purpose directly involves considerable modification to the design of the cupola, which are often sufficient to make the cupola impracticable. It is frequently stated that the use of pre-heated blast in the foundry cupola does not appear to have any advantages, and, broadly speaking, the writer is in agreement with these views.

(To be continued.)

Aluminium-Alloy Permanent-Mould Castings.—IV.

By Robert J. Anderson, D.Sc.*

Kinds of Alloy Used.

The development of the permanent-mould process for the production of aluminium-alloy castings has brought a new series of problems for solution by the light alloy metallurgist, and it has incidentally resulted in a variety of new alloys being developed for particular purposes. As stated in a previous article, the permanent-mould process has greatly broadened the field for aluminium-alloy castings, and since the permanent-mould-cast product is superior to the sand-cast as regards mechanical properties and susceptibility to heat treatment, it has also broadened the field for the use of heat-treated aluminium-alloy parts.

Any commercial aluminium alloy *can* be cast in permanent moulds, but it is not always feasible to attempt to put certain alloys into production. The regular run of alloys now used in sand foundry practice are being poured in permanent moulds, but particular alloys have been developed for specific purposes. From the point of view of the permanent-mould founder, the alloy to be chosen depends primarily upon its casting qualities, the nature of the casting, and the particular properties desired. In general, the alloy should have good casting qualities, since an alloy which gives difficulty in operation at the moulds may be uneconomical as a foundry proposition. Casting behaviour is a quality not easily defined in a precise manner, but is something which is determined by men experienced in the production of cast parts. Essentially, it means that the alloy should be well fluid (flow freely) at the proper casting temperature, have low contraction on freezing (as well as low liquid and solid contraction) in order to minimise cracks and shrinks, cast soundly with freedom from blowholes and porosity, give clean castings (*i.e.*, free from hard spots and inclusions), and not stick to the mould walls and cores. In practice, it is well-known that certain alloys cast with a lower percentage of wasters than others, and when the difficulties of permanent-mould casting are considered, the desire of the permanent-mould founder for alloys which have good casting behaviour is not far to seek.

The great difficulty in obtaining good castings with low waster-loss in the permanent mould process, when using aluminium alloys, is due to the high contraction in volume of these alloys on freezing, and their high thermal expansion in the solid state. Low-strength at elevated temperatures is also an important factor adding to the difficulties of the process.

Factors Affecting Casting Behaviour.

The chief factors affecting the casting behaviour of aluminium alloys in permanent moulds are fluidity and contraction.

Fluidity is governed by the temperature and the composition. In general, the higher the temperature the more freely and quickly does the alloy flow. Little is known as to the effect of composition on fluidity, *i.e.*, viscosity, but high iron-content in an aluminium alloy increases the viscosity. In general, alloying elements which raise the melting point of aluminium increase the viscosity for a given pouring temperature. Fluidity is a function also of surface tension, and no data are available as to the surface tension of different aluminium alloys. Practical experience has indicated that certain alloys have greater fluidity than others. Incidentally, the fluidity is affected by the amount of scrap in a melting charge, the size and shape of such scrap, the number of remeltings, and the degree of oxidation.

In sand practice, other things being equal, the alloy having the lowest contraction on freezing and the lowest coefficient of thermal expansion in the solid state is the most suitable for casting. The greater the contraction the greater the tendency to cracking. The contraction in volume of substantially pure aluminium on passing from 700 deg. C. to the solid state at the melting point is 7.2 per cent., while that of the 92:8 aluminium-copper alloy is a little less. The feeding of the heavy contraction of the aluminium alloys is an important factor in obtaining good permanent-mould castings. Alloys having very low contraction, like the 87:13 aluminium-silicon alloy, are not good for permanent-mould work, particularly where there is complicated coring with collapsible cores. The reason for this is that an alloy of very low contraction does not shrink enough to permit ready extraction of the cores and casting, and hence causes slow and difficult mould operation. On the other hand, alloys with very high contraction, like high-iron-bearing alloys, shrink severely around the cores, hold them fast, and cause "sticking" in the moulds. An alloy with intermediate contraction, *e.g.*, 92:8 aluminium-copper and certain modifications thereof, works satisfactorily. Considerable data are available on the contraction of light aluminium alloys, values for some 40 alloys being given in a Paper by the writer.†

Silicon is the most efficacious additive element that can be used for reducing contraction. The reason for this, as is known, is that silicon expands on freezing, and hence counteracts the normal contraction of the various alloys. Of all the metals and metalloids, only silicon and bismuth expand on freezing. An addition of silicon is indicated, especially in permanent-mould practice, to reduce the contraction of aluminium alloys in general. Silicon additions, incidentally, conduce to soundness.

Increasing iron-content increases the contraction and conduces to serious draws and bad cracks. A low iron-content is especially desirable in silicon-bearing alloys, and experience indicates that the iron-content should preferably be not over 0.6 per cent.

Owing to the high coefficient of thermal expansion of aluminium alloys, permanent-mould castings will crack if not removed from the moulds at the proper time. Alloys having lower thermal expansion give fewer cracked castings than those with higher expansion. Further, as regards cracking on casting, alloys having higher strength at elevated temperatures crack less readily than those having lower strength. Since high-strength at elevated temperatures is desirable for some types of permanent-mould castings, the use of additive elements to secure this property, *e.g.*, nickel, helps to reduce the number of wasters due to cracking. Also, alloys having higher impact resistance at elevated temperatures crack less readily than those having lower resistance, particularly in permanent-mould practice, where the casting is jarred and struck during removal of cores and extraction from the mould.

Particular Alloys Used for Casting.

For the general run of castings in the United States aluminium-copper alloys containing 8 to 12 per cent. copper are used. The 90:10 aluminium-copper alloy, when cast in permanent moulds, has about 30 per cent. higher strength than the same alloy sand-cast, as well as higher elongation; this alloy machines well. For castings which are to be polished various aluminium-copper-nickel alloys are employed; the addition of nickel to aluminium-copper alloys gives better surface finish and such alloys retain their lustre well. Aluminium-silicon, aluminium-copper-silicon, and aluminium-copper-nickel-silicon alloys are used for castings where considerable elongation is desired. Certain of these silicon-bearing alloys have tensile strength of 12.5 tons and elongation of 6 per cent. For bearings certain piston-alloy compositions are used, as well as aluminium-copper-nickel alloys.

Of specific aluminium alloys now being cast in regular production in permanent moulds, the following may be mentioned:—95:5 aluminium-

* Consulting Metallurgical Engineer, Cleveland, Ohio.

† R. J. Anderson, "Linear Contraction and Shrinkage of a Series of Light Aluminium Alloys," Trans. Amer. Foundrymens Assoc., Vol. 31, 1924, pp. 392-446.

copper; 92:8 aluminium-copper; 90:10 aluminium-copper; 88:12 aluminium-copper; 95:5 aluminium-silicon; 90:10 aluminium-silicon; 92:3:5 aluminium-copper-silicon; 90:4:4:2 aluminium-copper-nickel-silicon; certain alloys of the duralumin type; "Y" alloy (92.5:4:1.5:2 aluminium-copper-magnesium-nickel); and the usual run of piston alloys, *e.g.*, 89.7:10:0.3 aluminium-copper-magnesium. The foregoing are nominal compositions, and certain variations are met with in practice.

In general, purchasers of permanent-mould castings may do well to allow the producer some latitude as to composition of alloy, unless particular specifications as to composition must be met. In any case, it is well to ask the advice of the manufacturer before drawing specifications as to composition, strength, and hardness. The progressive permanent-mould founder has, or should have, the necessary data on alloys to provide all information needed by consumers of castings. Special heat-treatable alloys of the duralumin type are cast where very high tensile strength and hardness may be required.

Mechanical Properties of Permanent-Mould-Cast Aluminium Alloys.

The tensile strength of permanent-mould-cast bars (0.505-in. test-bar, unmachined) varies from about 8.0 to 14.2 tons per sq. in as freshly cast, with elongation in the range 0.5 to 10 per cent., and Brinell hardness in the range 40 to 120, depending upon the composition. Heat-treated alloys have properties in the following range:—Tensile strength, 10.7 to 20.1 tons per sq. in.; elongation, 0.5 to 8 per cent.; and Brinell hardness, 70 to 160. Thus, a very wide range of mechanical properties is obtainable to suit a variety of requirements. The tensile properties of permanent-mould-cast (chill-cast) aluminium alloys are very markedly affected by the shape of test-bar, method of gating, speed of pouring, number of bars cast together in a mould, temperature of mould, and temperature of alloy when poured, and these items naturally affect the properties of permanent-mould-cast parts. Tensile bars with sharp fillets are badly stressed. A flat bar with long conical fillets appears to give the most uniform results.

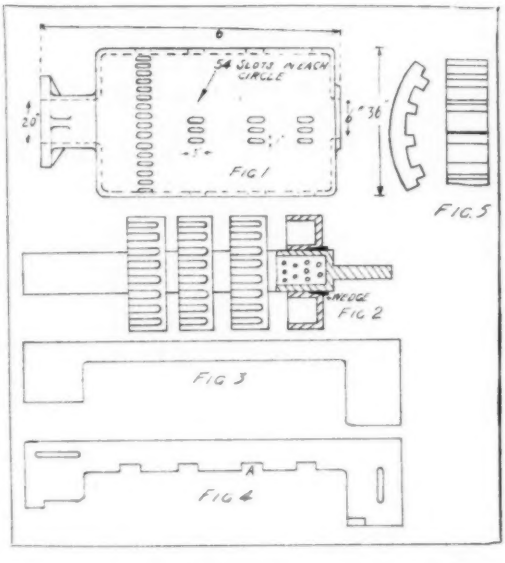
The mechanical properties of two alloys as chill cast and sand cast are as follows:—90:10 aluminium-copper, chill cast; tensile strength, 11.6 tons per sq. in. (sand cast, 8.8 tons); elongation, 2 per cent. (sand cast, 1 per cent.); and Brinell hardness, 80 (sand cast, 70), under 500 kg., 10 mm., 30 secs.; 95:5 aluminium-silicon alloy, chill cast; tensile strength, 9.8 tons per sq. in. (sand cast, 8.4 tons); elongation, 6 per cent. (sand cast, 4 per cent.); and Brinell hardness, 43 (sand cast, 40).

Special Manganese-Steel Rail.—Based upon the se for several years of a rail of special manganese steel by the Delaware, Lackawanna & Western Railroad, a United States patent (No. 1,568,822, January 5, 1926) has been granted to Howard J. Force, engineer of tests of that railroad, Scranton, Pa. The primary object of the invention, the patentee states, is the provision of a rail steel which is not only superior in physical properties, whereby breakage, rapidity of wear and disintegration are reduced, but also whereby transverse fissures are very materially eliminated. Another object is the avoiding of certain difficulties and losses ordinarily encountered in the manufacture of steel rails under present processes. He states that a further object is to secure a steel of superior quality which makes it possible to reduce the size of rails, if desired. The inventor claims that the steel which he has evolved, as described in the patent, will increase the length of the life of the rail, not only as to wear, but also that it will materially reduce disintegration and piping or seamy rails. He also claims that a rail made of this steel will withstand the standard drop test with greater deflection and will show a higher average hardness and stiffer section than the present steel rail. The inventor's claims are put in the following form: (1) A rail made of steel containing carbon, from 0.30 to 0.85 per cent.; manganese, from 1.15 to 1.90 per cent.; phosphorus, not to exceed 0.05 per cent.; and silicon, not to exceed 0.30 per cent. (2) A rail made of steel containing carbon from 0.30 to 0.85 per cent.; manganese, from from 1.15 to 1.90 per cent.; phosphorus, not to exceed 0.05 per cent.; silicon, not to exceed 0.30 per cent., and other elements not to exceed 0.25 per cent. each.—"The Iron Age."

Moulding a Medium-sized Strainer.

By J. H. List.

Castings coming under this heading and approximately the sizes given in Fig. 1 generally present some interesting problems. The smaller sizes of strainers are usually made from more or less standard patterns, and naturally entail no interesting points. The question of producing such strainers as are shown in Fig. 1 is mainly one of price. It is, of course, understood that if the expense of a proper pattern and core boxes is no object, then no real problems arise. Where keen competition has to be met foundrymen have radically to depart from the conventional methods of manufacture. The main question to keep in mind in tackling such jobs is covered by the old adage, "Penny wise, pound foolish." Thus, if the complete pattern will cheapen the production, then, of



course, that is the better method. It will be noticed that the total suction area is equal in area to twice the main area. Thus an area of 20 in. equals 314 sq. ins., and the total area of all the slots equals 628 sq. ins. This difference in areas allows for some of the slots making up. Fig. 1 shows an elevation of the casting.

The largest diameter barrel will have to be made larger in the body, or else the loam and straw bands will collapse under the fluid strain. Fig. 2 shows a method of doing this, which enables the barrel to be removed from the casting endways. The rings will then have to be broken up inside the casting in the fettling shop. For this reason they should be made as light as possible. Fig. 3 shows the board for striking up the core. After this operation a liberal coating of blacking wash to form a parting should then be applied on the core.

Fig. 4 shows the board for striking on the pattern thickness. The notches shown at A will form continuous bands, which will make core prints in the mould.

Fig. 5 shows a portion of the dry-sand core, which is ⅛th the circumference of the body, so that six cores for each band will be required. These cores will form the slots in the body. After the mould is made, these band cores should be securely fastened in top and bottom parts with wire nails, and tucked with sand. The mould then may be dried.

By this method, there should be no flash between the hand cores and the body core; care, however, should be taken in securing the body core down to prevent flotation.

A Good Steel Casting can be composed of: carbon, 0.28; silicon, 0.3; and manganese, 0.69 per cwt., which should bend through a complete right angle before breaking.

Institute of British Foundrymen.

East Midlands Branch.

ANNUAL MEETING.

The annual meeting was held at The College, Loughborough. Mr. E. Stevenson (Nottingham) presided over a good attendance of members.

The President (Mr. E. Stevenson), in moving the adoption of the balance-sheet, referred to the sound financial position of the Branch, the economical manner in which it was conducted, and that he was pleased the East Midlands Branch had not required its full quota.

The Secretary (Mr. H. Bunting), in submitting his report for the year, spoke with pleasure of the interest taken in the Branch by the members, and of their attendance at the meetings. The membership at the end of the year was 81, as against 80 at the commencement, whilst during the period under review three members had been transferred to other branches.

The Branch library was, without doubt, a source of usefulness to the members, the books having been called for on twenty-three occasions.

The election of officers was as follows: President, Mr. E. Stevenson, Nottingham: Vice-Presidents, Mr. H. Pemberton, Mr. J. E. Cox, and Mr. J. Lucas; delegates to General Council, Mr. T. Spiers and Mr. B. H. Vaughan; Hon. Secretary, Mr. H. Bunting; Auditors, Mr. T. Goodwin and Mr. H. J. S. Hilton; members of Council, Mr. C. N. Bigg, Mr. A. E. Peace, and Mr. T. H. Hawley.

Presidential Address.

The chair was then taken by Mr. S. H. Russell, and Mr. Stevenson delivered his Presidential address, in the course of which he said:—

Gentlemen,—There has been no time in the history of the country when technical education has been of such vital importance as it is at the present time, and the need is quite as great in our branch of engineering as in others.

The designs and specifications of our clients are becoming more complex every day. Demands which a few years ago were considered to be abnormal are now everyday occurrences, and those who do not take advantage of technical education are very soon left behind.

There are still many who do not think it necessary to spend a few hours per week in studying the whys and wherefores of the operations performed every day in the foundry. The man who does a thing, and knows why he does it, is far superior to the man who works by the rule-of-thumb.

The facilities for educating ourselves have increased considerably. More and more technical books are added to our libraries every year, books written by men who have made a life-study of their subjects.

There are still many who think it is to their advantage to find out things by their own experience. Such a system is too costly, and wastes too much valuable time. The place to begin experimenting is where the other fellow left off, otherwise no progress is made.

The most interesting way of getting information on any subject is by hearing a lecture and joining in the discussion, or, better still, by giving a lecture and replying to the discussion. The best way to study a subject is to write a paper on it and allow it to be discussed. In order to write a paper one must study the subject from all points of view, and the more debatable points there are in it the better the reception it will have. The writer of a paper will sometimes eliminate all obvious facts for fear of being too elementary; but are they obvious? To some perhaps, but not to all. A statement made by one of the lecturers last year on the venting of top-parts appeared to some to be obvious, but it caused considerable discussion and proved to be a distinctly debatable point. One can generally take it for granted that a lecturer has more at the back of his mind than he writes in his paper, and only by healthy discussion is that obtainable. A lecturer preparing a paper is generally so enthusiastic that he finds the paper much too long, so he proceeds to cut it down. We require the statements he has cut out quite as much as those he has left in, and the way to get at them is by discussion. A lecturer who is master of his subject delivers his discourse with the idea of handing his information on for the benefit of others, and he delights in a good discussion, as he realises his efforts are appreciated. On the other hand, the man who writes a paper for the sake of getting more knowledge of the subject, is amply repaid by the additional information he receives in the discussion.

The discussion is really the best part of a paper; we are then on level ground and on equal terms. There are many who refrain from entering the discussion of a paper for fear they may be expressing ignorance. There was never a greater mistake. Sometimes a simple and apparently obvious question may lead to a very varied discussion, and I do want to give every encouragement to members to enter freely into discussions. I quite realise it is a very difficult problem for some to stand up and express their opinion on a subject, but it must be remembered that very few are born orators, and even the greatest speaker had to make a beginning some time or other, and no doubt felt very nervous at the first attempt. It is all part of our education, and should be looked at from that point of view, and whatever misgivings we may have it is greatly outweighed by the satisfaction of knowing that we have given our contribution to a very enjoyable meeting.

The short paper competition, which takes place to-night, was instituted with a view to bringing out some of the hidden talent we know we have in this Branch. We have had papers from many of our members in the past, and we are looking forward to others presenting papers in the future, and it is hoped that this short paper competition will be a stepping-stone to greater efforts.

Short Paper Competition.

The President then called upon Mr. J. F. Driver to read the Papers submitted, explaining that the members would, after the reading, give their decision as to the best Paper received, which would then be put up for discussion.

The Paper selected (out of nine submitted) was "The Production of Small Castings by the Sand-Slinger," by Mr. H. J. Beck, of Derby.

Production of Small Castings by the Sand-Slinger.

This type of machine, which most of the members have seen in operation making 6-in. pipes and also larger castings, is easily adapted to the making of small castings on high-class repetition work. By small castings is meant castings from 10 to 30 lbs. in weight, two, four, six or eight castings per box, the box, say, 20 in. × 20 in. × 7 in., lifted by hand.

This machine rams this type of box perfectly when used in conjunction with stripping machines, and, in addition, gives excellent results when used with ordinary metal pattern plates. It is essential that good metal patterns be provided with plenty of taper wherever possible, well-finished iron patterns being preferable, as brass and aluminium become so easily bruised where there are sharp corners. One of these machines is installed in a malleable iron foundry in this district, and is doing good service. It is delivering, for a normal day's output, over 200 boxes per day, 20 in. × 20 in. × 7 in., containing two castings in each box, each casting weighing 26 lbs. These castings come out very uniformly in size, weight and contour, and perfectly true to pattern. They are definitely high-class castings, each of the desiderata mentioned being essential, as they are machined in jigs. The figures mentioned are not the limit to the output of this type of machine. To obtain the best output from the sand-slinger it is most desirable to keep it continually ramming throughout the whole day, but the greatest difficulty that presents itself is getting

the boxes on and off the machine in readiness. The output stated is obtained by 14 men and 6 boys, whose various duties are: one man for machine-operating; four men to place the boxes on the machine and also to remove them and close them when finished; one boy to clean the patterns and to strickle off the moulds; two boys to core and finish off the copes; one man and boy to finish and core the drags; one boy to dress cores and clamp boxes, and the remaining eight men to cast, shake out, get out the castings, knock off gates, mix and riddle sand. This gang is piece work on an "all-in" basis.

The weight of one box is: Cope, 1 cwt. 2 qrs.; drag, 1 cwt. 1 qr.; cores, 1 qr. 12 lbs.; and castings, 1 qr. 24 lbs., making approximately 5 cwts. per box in all.

This machine is driven by electricity and travels into the sand pile under its own power, collecting the sand from the floor by means of a right- and left-hand cutting screw conveyor, which conveys the sand to the centre of the machine, where it is elevated by means of a bucket elevator and deposited on the screen of an oscillating riddle. This is so constructed that scrap "gaggers" cores, etc., which are in the sand, will slowly work down into the chute and then into the scrap box, which is mounted on the main arm. The riddled sand is conveyed by the oscillating riddle into a hopper, mounted on the impeller arm, above a belt which conveys the sand into the impeller head. This head discharges the sand into the mould at the rate of 10 cub. ft. of rammed sand per min. The ramming capacity can be regulated by the speed it is fed into the sand pile. The impeller head had a 9-ft. radius, the right and left cutting screw conveyor is 11 ft. wide, and the machine requires a bay of at least 15 ft. wide and 200 ft. in length.

DISCUSSION.

Mr. Spiers said that considering the initial capital outlay, the power required to drive the machine, and the output obtained by 14 men and 6 boys, he could not agree that the result warranted the case.

Mr. Beck replied that the initial outlay was not such a serious item. The machine, with accessories, would not cost above £1,500 to fix, and the machine he had in mind, although not at present working to its full capacity, yet had an output of 20 tons per week

The labour was 16 labourers and 4 boys—no skilled men were necessary. To obtain the same output from jolt-machines worked by compressed air, the capital expenditure for plant, compressors, motors, jolt-ram turnovers, would be heavier than for a sand-slinger. The compressor would require more h.p. than to run a sand-slinger, which handled all the sand. He felt sure Mr. Spiers would be happy if he could get an output of 20 tons light grey-iron castings per week—and it must be remembered that malleable was 30 per cent. more expensive to produce than grey iron—from the labour mentioned.

Mr. Russell concurred with Mr. Spiers as to the results obtained. He would like some information as to how the bars of the top part were arranged, and if any difficulty obtained in adequately ramming under the top bars—if there were any—and if there were no bars, he would like particulars of the grid. He noticed the author said the patterns must be provided with plenty of taper wherever possible. Why was it necessary to have a lot of taper for a sand-slinger?

With regard to the author's statement that iron patterns were preferable, he (Mr. Russell) would have thought that, owing to the difficulty of making alterations to iron patterns, brass patterns would be better. He could see no excuse for the bruising of patterns if they were mounted on a moulding machine.

He agreed that the sand-slinger was the machine of the future, but to house it a special building was necessary, and £5,000 would be a conservative estimate of the capital outlay. He noticed that four men were used for placing boxes on the machine, taking them off, and closing when finished. This seemed to him a lavish number of men for putting boxes on and off, also eight men engaged in casting, shaking out, getting out the castings, and riddling sand seemed to him extravagant, and some more economical method should be introduced to save some of that labour.

Mr. Driver asked what type of labour was necessitated by a sand-slinger.

Mr. Bunting asked as to the method adopted of supplying the boxes to the machine. If there was only one plate being worked it would not be possible to keep the sand-slinger at work all the time. There should be some sort of a revolving table to keep boxes going to the machine. If the sand were too wet, had it any effect on the efficient working of the machine? Again, how was the sand held up to the surface of the pattern?

Mr. Beck replied that no special bars were necessary in the boxes, cope or drag, the boxes having originally been made for jolt ramming, and the bars are simply 2 in. vertical in the form of a grid. No more taper is necessary for the sand-slinger than for other methods of machine moulding, and he had only impressed this as an advantage for easy working.

With reference to iron patterns, these are preferable for use with the machine, as there are small pieces of scrap or shot which sometimes passed through the impeller head and made small abrasions on wood or brass patterns. Wood patterns, brass reinforced, had been used to make over a thousand moulds, without showing a great amount of wear, but it was a different proposition when thirty or forty thousand are required carrying a very smooth skin.

No special building was necessary; any foundry with a modern crane and enough floor space was suitable; in fact, the trouble was that most of our foundries are not sufficiently large to enable this machine to be worked to its capacity. The £5,000 capital mention would be three times too much.

With reference to the number of men putting on box parts, taking off the moulds, and closing them after they were cored. With 20-in. × 20-in. boxes going on the machine at the rate of 50 box parts per hour, that is, placing the box on the pattern, off the pattern on to the floor in case of drags, on to the pattern, off the pattern on to trestles for coring, and off the trestles on to moulds, there was not too much labour about the machine: the only way of working this machine to the best advantage was to get the moulds away as fast as they are made.

With regard to the eight men casting, shaking out, getting out the casting, knocking off the gate, and mixing the sand. These men were fully employed, as malleable was a more difficult proposition than grey iron. Casting three times per day from the air furnaces was no easy job; in fact, 400 castings to be poured and 400 hand ladles to be emptied to cast a day's work showed why the labour was necessary.

In the foundry he had in mind, which produced some 200 tons of castings per week, and where hundreds of other classes of moulding machines were at work, the sand-slinger had been proved to be the cheapest method of producing castings.

With respect to the method of getting boxes to the machine with the type of sand-slinger which had been referred to, a tractor machine was used, which meant that the machine was taken to the sand and boxes, which was the more economical. Sand must not be too wet, but rather on the dry side, as there was danger of hard moulds from wet sand; it was better to use drier sand and ram harder.

Annual Dinner of Newcastle Branch.

The annual dinner of the Newcastle Branch of the Institute was held on February 13, at Tilley's Restaurant, about 80 members and ladies being present. The Branch-President, Mr. M. B. Herbst, was in the chair, and amongst the guests were the Lord Mayor of Newcastle-on-Tyne (Councillor Anthony Oates). Sir Archibald C. Ross, K.B.E., Mr. J. Cameron, President of the Institute; Engr.-Commdr. C. J. Hawkes, R.N., and Dr. J. A. Smythe, of Armstrong College, Newcastle; Mr. H. R. Cullen, Principal of the Marine School of South Shields, and Major K. C. Appleyard.

After the toast of "The King" had been honoured, Mr. W. J. Paulin proposed that of "The Trade and Commerce of Tyneside." He referred to the great depression in the shipbuilding and allied industries which they were experiencing at the present time, and expressed the hope that in his reply the Lord Mayor would be able to give them some better hope of the future.

War-Time Invasion and Local Rates.

The Lord Mayor of Newcastle (Councillor Anthony Oates), responding, said that he did not think that he should be expected to know more about the trade prospects than others present who were actually engaged in the engineering industry. He thought that to some extent, at any rate, we were reaping what we had sown, in that, for many years prior to the war we had been educating foreigners in the making of ships and the building of engines, the result being that we now have many foreign competitors. He was optimistic enough to believe, however, that the British working man had not lost his cunning, and that in spite of the opposition of other nations we would again rise to our old position.

Referring to the local unemployment, he drew particular attention to the fact that a considerable amount of it was accounted for by the large numbers of men who came from other parts of the country during the war. What this meant to the city, he said, was shown by the fact that the Guardians' rate was now 5s. 1½d. in the £, as against 1s. 2½d. in pre-war days—this altogether apart from the dole. He was strongly of the opinion that these heavy charges, which were really a legacy of the war, should be born by the nation as a whole and not fall on the local rates of the city. If relief from these heavy rates could be obtained he thought there were possibilities of several new industries being brought to the Tyne. He then referred to the various schemes for new streets, quayside extension and other matters which had been rejected recently by a poll of the ratepayers. He considered that sooner or later these extensions would become essential and that when they were made their cost would be considerably more than the present estimated cost. He was of opinion that the Tyne was an important enough river to take liners direct from America and Australia, but this could not be done until it had better quayside facilities.

The toast of "The Guests" was proposed by Mr. Victor Stobie, who, in a short speech, gave them a cordial welcome on behalf of the Branch.

Importance of Output.

Sir Archibald Ross responding, said that he regarded foundrymen as the fruit of the earth—they were the apple of engineering, and were sound to the core. (Laughter.) He hoped to see the day when they would have moulders in the drawing office on the same lines as at his own works—they had introduced a boilermaker into the office.

There had never been a time like the last decade, when such tremendous calls on the iron-founding industry had been made. He agreed with other speakers that British workmen were the best in the world, but he would like to say that they now had no longer the monopoly which they enjoyed in the early days of engineering, and that although they might be the best workmen, it did not follow that they were the best "outputters." As long as they had people preaching that there was nothing right in the country except the downthrow of their institutions they would have trouble.

He was all for free speech and a free Press, but, also, he was all for letting people see the other side, and they must not let the extremists run away with their better judgment.

In proposing the toast of "The Institute," Major K. C. Appleyard made some humorous comments on the Lord Mayor's remarks on the subject of rates. He thought that the Institute was doing very good work indeed, one of the points which appealed to him particularly being that it was essentially a practical one and that it deliberately sets out to attract the practical man, and especially the working man who earns his living by foundry work. He referred to the draughtsman's lack of knowledge of moulding, and strongly recommended that draughtsmen should join the Institute. He was of the opinion that one of the most important things that this Institute was doing, and could do, was the encouragement of junior apprentices. He hoped that the Junior Section of the Newcastle Branch, which was the first Junior Section formed, would receive more and more support from the senior members, and particularly from the various firms in the district. He asked these firms to give every support they could to encourage their boys to join and to take the opportunities which were offered for them to see over other works and attend the technical meetings.

He hoped the Institute would never grow to the stage of becoming purely theoretical, and that it would encourage foundries in the district to know that large numbers of working moulders joined the Institute with the object of learning more about their work.

On looking through the membership list of the Newcastle Branch, one point struck him, and that was that there were not sufficient subscribing firms for a district of this nature. He thought it was up to any firm who could afford it, either then or in the future, to become a subscribing firm and thus give the Institute support both morally and financially.

Extending Institute's Work.

Mr. J. Cameron, President of the Institute, responding, said that it was a very great pleasure for him to be present that evening, and he was very glad to see the ladies were invited. Referring to the progress of the Institute, he said that a very healthy sign was that there were requests from various districts for new Branches. A new section of the Scottish Branch had been formed recently, and a meeting was to be held the following week at Middlesbrough, when they hoped a Branch would be started in that district. He referred also to the very good work being done by the various Junior Sections, and said that the value of that work was becoming more apparent year by year. He thought it was one of the good points of the Institute that it aimed at encouraging men to take a pride in their work and to come forward and take part in discussions, or even give papers at the meetings. Personally, one or two of the best Papers he had ever heard had been read by actual working moulders.

Continuing, Mr. Cameron mentioned the invitation to visit the American Convention and Exhibition later in the year, and hoped that there would be a good party of British foundrymen going, as it was undoubtedly a trip which was worth taking.

In conclusion, he appealed for greater support for the Institute, particularly from employers: he knew that it was often difficult for them to take a practical interest and attend the meetings themselves, but he hoped they would do everything in their power to encourage their staff and foundry workers to attend the meetings, and also support the Institute by becoming subscribing firms. He was sure they would find that their workers would benefit by attending the meetings, and that they would come away with new ideas and renewed interest in their craft.

In proposing the toast of "The Ladies" Mr. Jas. Smith made a humorous speech, which was responded to by Mrs. J. W. Frier.

LANCASHIRE BRANCH.—JUNIOR SECTION.

Foundry Materials Under the Microscope.

On February 20, at a meeting held in the College of Technology, Manchester, Mr. C. F. Brereton gave a talk on the use of the microscope in the foundry.

The subject was a large one, and whilst it was unfair to suggest that everybody connected with founding should become an expert, it was important to have an insight into practical metallography sufficient to enable them better to understand the internal structure of the metals with which they worked, and also the numerous photo-micrographs which so often illustrated articles of practical importance in the technical Press.

Metallography was almost entirely superseding

the old and unreliable method of judging quality by fracture. It was a more certain guide to the foundryman, and helped in the avoidance and repetition of serious failures not solely connected with chemical composition.

Much good work could be done by foundry workers without the necessity of going deeply into the optics of microscopy. The various types of metallurgical microscopes were briefly explained, and before proceeding to actual practical examples, the chief constituents of cast iron and the simpler copper alloys were described.

Troubles due to cores, mould materials, and construction were usually self-evident. It was not usually necessary to have recourse to a microscope to find out the cause of blowholes, but it did pay to examine such wasters. Pin holes often resulted as a result of too low a pouring temperature, and more especially was this the case when the sulphur was at all high. In such a case patches of manganese sulphide were often in evidence in the metal surrounding the pin holes. The effect of not keeping up heads during pouring operations was illustrated. Surface chilling, a direct effect of a too liberal use of the swab in greensand work, was a difficulty which the microscope easily elucidated. Graphite, the controlling element of cast iron, only appeared in its true light when the metal was examined microscopically. The effect of its size, distribution, and shape was enormous, and the microscope was the only means of revealing when the best possible arrangement had been satisfactorily achieved. The effects of composition, mass, and rate of cooling on the graphite was emphasised. Segregation, due to poor design alone, or coupled with unsuitable metal, was easily detected, and was among the commoner causes of failures of cast metals.

Chaplets, steel tubes, and similar inserts were always potential sources of trouble, and when new designs were to be tried, a good plan was to reproduce, as a test piece, that portion of the casting in which those inserts were incorporated, and then to section and examine it for solidity. The microscope at once revealed to what extent perfect welding was attained.

"Freaks" were fairly common occurrences in the malleable shop, and were often enigmas which had remained unsolved until the microscope had helped to do so. Edge recarburisation was fatal to the ductility, and this was but one example of a problem which had long remained unsolved.

In the non-ferrous foundry, with its innumerable alloys, the microscope was invaluable. In leaded-copper alloys segregation was the chief trouble; the microscope, however, infallibly detected this fault.

With gunmetal, brasses and aluminium alloys amenable to heat-treatment, scientific control was only possible when the microscope was relied upon to check the efficacy of the treatment.

White metals, either lead or tin base, were especially susceptible to the ill effects of high pouring temperatures and incorrect cooling speeds, and was yet another important instance where metallographic control was very helpful.

The study of sands and facing materials was briefly touched upon, and was cited as opening a field for the low-power microscope.

The lantern slides which so well illustrated the remarks of the lecturer were kindly lent by Mr. J. G. S. Primrose, and by kind permission of Messrs. Rhead and Ogilvie several microscopes were available for demonstration.

DISCUSSION.

In opening the discussion, Mr. Yoeman said that the lecturer had used the terms "eutectic" and "eutectoid"; what was the difference between these? Cementite, according to the formula given, contained three parts of iron and one part of carbon; how was that known? Sources of light for micrography had been but briefly mentioned; had the lecturer any experience of using blue or yellow light, and which did he consider the better? Where a vertical illuminator was used in the body tube, how was it that it did not obstruct part of the field of vision? With regard to burns, if the job were not hot enough it would crack when the liquid metal was added. Phosphide eutectic was a hard constituent; how could it machine without difficulty in the case quoted of a sugar-cane crushing roll in which the phosphide had purposely been allowed to segregate into small patches?

Mr. J. G. S. Primrose thought that the whole subject came to be one of £ s. d. The founder who could make practical use of the findings of the metallographer, could eliminate to a large extent the uncertainty which always existed when such knowledge was lacking. It was well to emphasise the unreliability of fracture as a criterion of quality. He had with him fractures of pigs which were utterly misleading.

The apparent No. 1 fracture iron had a No. 4 analysis; this was by no means an uncommon result of artificial cooling in the pig bed.

In reply Mr. Brereton said that an eutectoid had all the characteristics of an eutectic except one, namely, that it was formed from a *solid* and not a *liquid* solution. An eutectic had always a definite composition and a constant temperature of formation. As an example of an eutectic, the iron—iron carbide—iron-phosphide eutectic could be cited. Pearlite was an eutectoid. With regard to cementite, this carbide had been isolated by numerous workers and analysis showed it to contain 6.6 per cent. of carbon, the remainder being iron: from these figures the empirical formula was easily calculated. For illumination in visual work the frosted or opalescent electric bulb was recommended, as it gave a diffused white light. Mono-chromatic light only became necessary when photographs were to be made. Then green, blue, or yellow filters could be used; these were made of stained celluloid or a coloured liquid could be employed. Yellow filters gave good results for most purposes. It was a well-known optical fact that even if a portion of the tube was obstructed by a prism, still enough light passed, and on reaching the eye produced a perfect image. With burns sufficient heating was an essential if cracks were to be avoided, but, what was of equal importance, they should be made uniformly hot.

Phosphide eutectic was hard, but it was also brittle. Provided the percentage of phosphorus was not too high no undue hardness was encountered. In the case quoted only the binary eutectic was present. The tool chipped out the brittle constituent and left the face rough, which was the desired effect, in order to give the roll a biting surface.

Foundry Query.

Gear Wheels (page 124, Issue February 18).

I have made great numbers of these wheels for a considerable number of years, the mixture mentioned always gives coarse grains, just in the centre of rim, and invariably gives results as mentioned. I have always found satisfactory the following mixture for heavy gear blanks:—50 per cent. No. 1 L.S.W. and 50 per cent. scrap. This gives a close grain right throught on a blank rim 4 in. square.

London. F. C. B.

An Acid-proof Cement can be obtained by mixing together the following: Concentrated solution of silicate of soda with a quantity (according to stiffness required) of powdered glass to form a paste. This paste is, for all practical purposes, regarded as acid-proof.

New Type of Monorail. — A new form of monorail has been developed by the American Brass Company, Waterbury, Conn. The standard joist, which was originally used for the purpose, proved unsatisfactory because of the wear and deformation caused by high-speed trolleys carrying heavy loads. The soft steel of the beam hardened, apparently because of the rolling or hammering action of the wheels, and subsequently hardened pieces were torn loose, varying in size from small flakes to strips up to ¼ in. thick by 3 in. long. After various trials the construction finally adopted consisted of two special rail-steel angles resting on the bottom flange of a rolled joist, and riveted to its web. One leg of each angle was tapered to correspond with the standard flange angle of the beam, and the other leg was made straight and punched for riveting through the web of the beam.

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Box and Mould—after being Rammed—in position of being Rolled over.

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Sand jar rammed by "Shockless" device—Tabor Patent—without shock to the machine or surrounding moulds.

*** Machine not restricted to use of one size moulding box—any size can be used up to load capacity of machine.**

Good surface castings.

Pattern plates can be changed instantly without unfastening mechanism so that comparatively small quantities can be made economically.

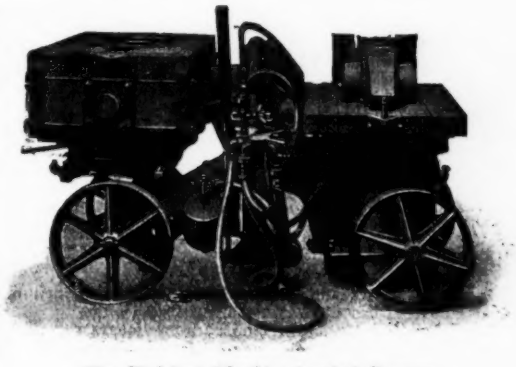
Perfectly straight draw ensured by mechanical guides of large surface to prevent wear and retain accuracy.

All moulds jar rammed in a few seconds and thoroughly uniform in density, ensuring minimum quantity of defective castings and less blow holes.

"All operations other than sand filling are completed in two minutes for any size of work within capacity of machine. To realise what this means, compare your present wage cost for the same work!"

CAPACITY.

SIZE	* Size of Moulding Box.	Straight Pattern Draft.	Nett Weight of load that can be rolled over at 80lbs. pressure.
18	18 in. wide. 36 in. long. 12 in. deep.	8 in.	450 lbs.
24	24 in. wide. 48 in. long. 15 in. deep.	10 in.	800 lbs.



The Finished Mould—showing Pattern after being drawn.

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Trade Talk.

Dorman, Long & Company, Limited, have an order from the Buenos Aires Great Southern Railway for 25,000 tons of heavy rails.

W. Brealey & Company, Limited, Russell Street, Sheffield, have removed to the Prospect Works, Hawksley Avenue, Sheffield.

The Hilex Iron & Steel Company, Joseph Rodgers & Sons, Limited, and L. M. Van Moppes & Sons have joined the Federation of British Industries.

The Ebbw Vale Steel, Iron & Coal Company, Limited, have been awarded the third contract for the supply of 100,000 steel sleepers to the Egyptian State Railways.

Vickers, Limited, Barrow-in-Furness, have an order from the Straits Steamship Company, Limited, for a fast turbine-driven twin-screw passenger vessel for service between Singapore and Penang.

Under the profit-sharing scheme of Royles, Limited, Irlam, Manchester, the shareholders receive 12½ per cent. on their investments for the past year and the employees 15 per cent. on their wages and salaries. The scheme has been in existence for seven years.

The Ransome Machinery Company (1920), Limited, of Windsor House, 46, Victoria Street, London, S.W.1, have received an order from Sir Robert McAlpine & Sons for four of their largest size concrete mixers, which have an unmixed batch capacity of 12 cubic ft.

The annual dinner of the Staff Society of Thos. Firth & Sons, Limited, has been held at Sheffield. Mr. H. Newbould presided, and those present included Mr. B. A. Firth, Mr. W. Firth, Mr. F. C. Fairholme, Mr. J. Smith and Mr. E. Middleton, the secretary of John Brown & Company, Limited.

To meet the further demands made by tube extensions, the generating plant at the Lots Road power station is being augmented. A fourth 15,000 kilowatt machine is under construction, and when this is complete the generating capacity of the station will be 102,000 kilowatts, or about 137,000 h.p. In addition two further boilers, having a capacity of about 50,000 lbs. per hour, are under construction for the steam generating plant, which already comprises 64 boilers, and these will be in operation during the present year.

The increased demand for electricity is shown by the order placed by the Stretford Urban District Council with the Metropolitan-Vickers Electrical Company. The order is for two rotary converter equipments, each of 250 kilowatts capacity. One set is being installed in the works of W. T. Glover & Company, Trafford Park; the other is for a new sub-station to be erected in Skerton Road, Stretford. The Skerton Road plant will work entirely without attendance. When the peak load occurs the rotary converter will start up automatically and connect its output to the system. When the load falls to a point at which the service of this extra rotary converter is no longer needed the plant will be automatically disconnected and brought to rest.

Obituary.

Mr. A. F. Woolhouse, works manager for Guest & Chrimes, brassfounders, Rotherham, died last week, aged 61.

Mr. W. Lees, chairman and managing director of T. & R. Lees, Limited, engineers, Hollinwood, died recently, aged 51.

M. Robert Pinot, vice-president of the Comité des Forges, the representative organisation of the French iron industry, has died at the age of 66.

Mr. J. McEwan, a director and previously secretary of Henry Walker & Sons, Limited, Gallowgate Foundry, Newcastle, has died at the age of 76.

Mr. H. Walker, consulting engineer, of Wynfield, Grange, West Kirby, Cheshire, died recently. The deceased, who had been associated with Cammell, Laird & Company, Limited, for 29 years, joined the firm in 1896, shortly after the completion of his apprenticeship, which he served with Fawcett, Preston & Company, Limited, Liverpool.

U.S. Manganese in 1925.—According to preliminary figures compiled by the U.S. Bureau of Mines for 1925, the domestic deliveries of manganese ore containing 35 per cent. and more of metallic manganese totalled about 97,500 tons, of 2,240 lbs., as against 56,515 in 1924. The ratio of the production of chemical ore to that of metallurgical ore decreased, while the production of chemical ore remained relatively constant for the two years.

Company Reports.

The Mint, Birmingham, Limited.—Dividend, 6 per cent. per annum (less tax) on preference shares, for six months.

Barrow Hematite Steel Company, Limited.—Debit balance, £68,313; debit balance brought forward, £15,561; debit of profit and loss account at December 31, 1925, £83,875.

North British Locomotive Company, Limited.—Preference dividend, 5 per cent., less tax; ordinary dividend for year, 5 per cent. less tax; £50,000 transferred from reserve fund.

Bruce Peebles & Company, Limited.—Dividend on ordinary shares for year, 10 per cent. per annum, together with bonus 5 per cent., both less tax; preference shares receive additional 2½ per cent., making 10 per cent. for year.

Mather & Platt, Limited.—Net profit, £260,885; income tax equalisation account, £40,910; brought forward, £182,855; available total, £402,830, final dividend on ordinary shares, 5 per cent, making 10 per cent. for year, plus bonus 5 per cent., both free of tax; carried forward, £178,281.

Personal.

Mr. R. M. H. Carlton has been taken into partnership by S. W. Carlton & Company, metal brokers, etc., 32, Lime Street, London, E.C.3.

Wills.

Earp, H. P., of Southfield Road, Middlesbrough, ironworks manager	£5,422
Forster, T. S., of T. S. Forster & Sons, Copperas Bank Forge, Sunderland ...	£5,364
Levick, T. S., of Endcliffe Grove Avenue, Sheffield, late of Swift Levick & Sons, Limited	£5,564
Whitfield, W., director and London representative of William Oxley & Company, Limited, Parkgate Steel Works	£3,260
Summers, F. B., of Froyle Place, Alton, Hants, lately a director of John Summers & Sons, Limited	£205,801

Blast Furnace Coke Research.

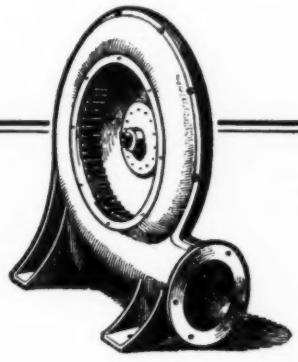
A development in research on coking problems has recently taken place in the formation of a committee to organise research on blast furnace coke. This committee, under the chairmanship of Mr. W. J. Brooke, of John Lysaght, Limited, includes representatives of the Midland Ironmasters' Association, the Lincolnshire Ironmasters' Association, and the Northamptonshire Blast Furnace Owners' Association. The main object is to identify and specify those characteristics of different cokes which render them of greater or less value as blast-furnace fuels. The work is being carried out under the direction of Professors C. H. Desch and R. V. Wheeler in the Metallurgical and Fuel Laboratories of Sheffield University.

The committee is constituted as follows:—Mr. W. J. Brooke (chairman), of John Lysaght, Limited (representing the Lincolnshire Ironmasters' Association); Mr. A. J. Bates, of the United Steel Companies, Limited; Mr. J. Crawford, of the North Lincolnshire Iron Company, Limited; Mr. A. Cooke, of the Frodingham Iron & Steel Company, Limited; Mr. S. J. Lloyd, of Lloyds Ironstone Company, Limited (representing the Northamptonshire Blast Furnace Owners' Association); Mr. R. Miles, of Newton, Chambers & Company, Limited (representing the Midland Ironmasters' Association); Professor C. H. Desch, Professor R. V. Wheeler, and Mr. E. C. Evans, of the National Federation of Iron and Steel Manufacturers, who acts as organising secretary. Mr. R. A. Mott, of the Department of Fuel Technology of the University, is general secretary.

A lecture, entitled "Drop Forgings," was given last week to the members of the Sheffield Section of the Institute of Metals by Dr. O. F. Hudson.

The Preswell Engineering & Welder Company, Limited, are being wound up voluntarily, with Mr. R. E. Starkie, 6, South Parade, Leeds, as liquidator.

The Empire Council of Mining and Metallurgical Institutions has accepted the invitation of the Canadian Institute of Mining and Metallurgy to hold the second Empire Mining and Metallurgical Congress in Canada in August-September, 1927.



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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—Increasing uncertainty as to the outcome of existing troubles in the labour world, both as regards the mines and the dispute in the engineering trade, has had a further retarding effect upon activity in the Cleveland iron market, and at the moment business is exceptionally quiet. But it must be remembered that the majority of the principal consumers of foundry pig had already bought on a heavy scale to cover their requirements over the current quarter, and in some instances for even longer periods, and thus have no immediate inducement to extend commitments until the future position becomes more clearly defined. In the export section inquiry is only on a moderate scale, while the further weakness of the franc makes business more difficult and tends to facilitate the importation of Continental iron. So far, however, quotations are unchanged as follow : No. 1, 73s. ; No. 3 G.M.B., 70s. 6d. ; No. 4 foundry, 69s. 6d. ; and No. 4 forge, 68s. 6d. per ton. These are export f.o.b. prices ; home prices are 6d. per ton less.

The Tees-side hematite market continues quiet with little actual business passing, the home demand having eased to some extent, with overseas inquiry in diminished volume, quotations ruling at from 77s. 6d. to 78s. for East Coast mixed numbers, with 6d. per ton premium for No. 1 quality. On the North-West Coast prices are firm, with Bessemer mixed numbers at £4 2s. 6d., c.i.f. Welsh ports ; £4 5s. 6d. to £4 7s. 6d. per ton, delivered at Glasgow ; £4 10s. per ton, delivered at Sheffield ; and £4 14s. 6d., delivered at Birmingham.

LANCASHIRE.—The almost chronic depression in the foundry pig markets in this area previously reported has been by no means lightened by recent developments in the engineering industry, and buying is now again limited in scope to hand-to-mouth transactions, with Welsh inquiries few and far between. Prices, however, keep up remarkably well. No. 3 Staffordshire, Lincolnshire and Derbyshire are all quoted at or around 76s. per ton, delivered Manchester, or equal distances, while East Coast hematite is offering at 77s. 6d. to 78s., on trucks at makers' works.

THE MIDLANDS.—Though the activity in foundry pig noted a few weeks ago has partially subsided, it is satisfactory to learn that local deliveries are being taken against forward contracts at a very fair rate, so that little iron is actually going into makers' stocks. Some Derbyshire makers are off the market for the time being, stating that they are waiting to see what develops in regard to fuel prices before they book further ahead. Ruling quotations are as follow :—Derbyshire No. 3 foundry, 67s. 6d. to 68s. 6d. ; Staffordshire No. 3 foundry, 67s. 6d. to 68s. 6d. ; Northants, No. 3 foundry, 64s. to 65s.

SCOTLAND. — Business in this area continues unsatisfactory, consumers generally contending that conditions are without visible improvement. Meantime, for small quantities smelters are prepared to accept 76s. 6d. for No. 3 Scotch foundry at furnaces, and for round parcels this price could, no doubt, be improved upon in some cases.

Finished Iron.

Throughout the manufacturing departments of the trade, complaints continue frequent of a scarcity of fresh business, the specifications in hand, as a rule, being insufficient in tonnage to ensure regular working of mills and forges. In South Staffordshire there is only a fair demand for iron at the moment ; the orders for crown quality are not so heavy or numerous as they were, and there is quite a noticeable lull. There is, however, no change in the price, varying from £11 the cheapest to £11 10s. per ton, neither is there any alteration in the quotation for nut, bolt, and fencing iron, which is £10 5s. to £10 10s. per ton delivered, but only scanty support is being given to the mills in connection with the latter, as circumstances compel the local manufacturers to go abroad for their heavy requirements. With regard to iron tube strip, it is reported that the demand is improving quite considerably, but quotations are the same, in the region of £12 10s. basis. Marked bar quotations are stationary at £14 per ton at makers' works, but with very little developing in the way of new business of any appreciable tonnage.

Steel.

The market for semi-products continues quiet, but there is fairly regular buying of billets, though in rather small lots. Acid qualities are a stronger market than basic, the latter still feeling sharply the effects of Continental competition. Prices of both acid and basic are unaltered. In the lower grades of rolled steel prices have dropped rather badly of late, owing to the severity of competition, especially in the export markets. After a long period of depression the heavy steel and engineering branches in the Sheffield district are beginning to look up again, and some of the armament works are rolling substantial quantities of armour plate. Railway and shipbuilding business is better. The lighter engineering branches are fairly well employed ; tool makers are busy, and makers of tool steel report expanding business, both home and overseas. In the tinplate market the inquiry is moderate, and the business recorded is almost entirely for spot lots and for near shipment, buyers preferring to cover their actual requirements only. The price shows no improvement ; 19s. 1½d. to 19s. 3d. having been freely accepted, although many works, holding the view that the "pooling" scheme will have an improving effect in the market ere long, will not sell below 19s. 6d.

Scrap.

Although still comparatively quiet, business in the various markets for scrap metal is, in individual cases, a little better, as reported in Scotland, where foundry material has been in slightly more active demand. In this district machinery cast-iron scrap still remains unchanged around 74s. to 75s. per ton. Ordinary cast-iron scrap is fairly firm around 67s. 6d. to 68s. per ton, and old cast-iron railway chairs are still being disposed of at 73s. 6d. to 75s. per ton. Light cast-iron scrap and firebars remain firm at 61s. 6d. to 62s. 6d. per ton. The above prices are all per ton, delivered f.o.t. consumers' works. In Lancashire, buying is on a limited scale and supplies are greatly in excess of the current demand. Ordinary machinery cast-iron scrap is quoted at 70s. to 72s. 6d. per ton, and textile machinery quality at 75s. to 77s. 6d., delivered.

Metals.

Copper.—Values of standard metal of late have been maintained at recent levels, with fairly steady persistence, and lacking unexpected developments, may be regarded as unlikely to undergo much change of importance during the current quarter. Consumptive demand for copper is comparatively quiet, but a good deal of rough bar material has recently been withdrawn from English warehouses partly for despatch to the United States for conversion into refined. Current quotations :—*Cash* : Thursday, £59 5s. ; Friday, £59 2s. 6d. ; Monday, £58 15s. ; Tuesday, £58 7s. 6d. ; Wednesday, £58 12s. 6d.

Three Months : Thursday, £60 5s. ; Friday, £60 2s. 6d. ; Monday, £59 17s. 6d. ; Tuesday, £59 7s. 6d. ; Wednesday, £59 12s. 6d.

Tin.—The exceptionally low level of stocks now held in home tin warehouses, amounting to about 1,800 tons, has stimulated the optimistic tendency of the market, which fully maintains its firmness. Buying by America was at one time very active, while it is reported that consumers in need of prompt parcels have found great difficulty in placing orders in New York, where the scarcity of spot metal became very acute. High premiums, apparently, have thus been exacted there, as have been generally experienced on this side. Current quotations :—*Cash* : Thursday, £291 ; Friday, £293 10s. ; Monday, £295 15s. ; Tuesday, £294 12s. 6d. ; Wednesday, £292 10s.

Three Months : Thursday, £281 5s. ; Friday, £282 10s. ; Monday, £285 15s. ; Tuesday, £284 10s. ; Wednesday, £282 10s.

Spelter.—Conditions in this section have developed an easier tendency, and it is difficult to discover any factor likely to materially influence the market in an upward direction. The metal has been weakened largely by the adverse American statistics indicating an increase in the stocks and a rather substantial expansion in production. Current quotations :—*Ordinary* : Thursday, £35 10s. ; Friday, £35 7s. 6d. ; Monday, £35 ; Tuesday, £34 15s. ; Wednesday, £34 17s. 6d.

Lead.—The market for soft foreign pig continues on the quiet side, consumption at home and abroad having fallen away materially, and although stocks are undoubtedly low, they are not yet sufficiently limited to cause anxiety. Old orders are certainly being worked off, but fresh business is not taking its place to any material extent, and so the trade is at present inclined to be different. Current quotations :—*Soft foreign (prompt)* : Thursday, £33 12s. 6d. ; Friday, £33 10s. ; Monday, £33 2s. 6d. ; Tuesday, £32 2s. 6d. ; Wednesday, £32 2s. 6d

OEHM'S

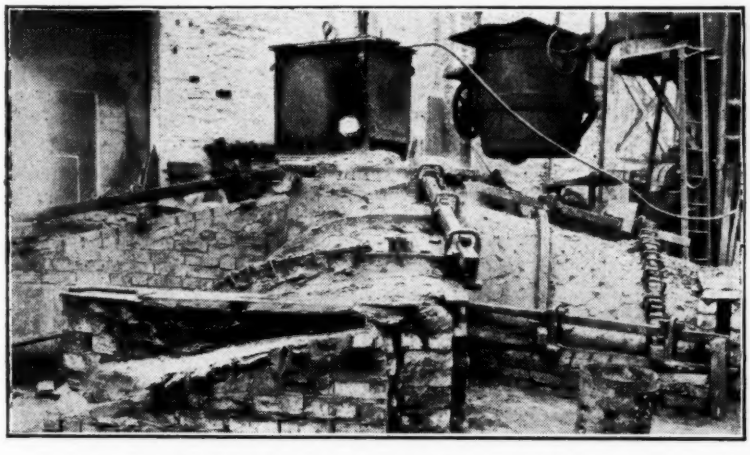
PATENT

HEATING ELEMENTS

(ENTIRELY BRITISH MADE.)

HALVE YOUR FUEL BILL

The application of Oehm's Patent Heating Element results in a 50% saving in fuel consumption, and the cheapest form of fuel—hard coke, breeze and even refuse—can be used. It works twice as quickly as any other method and its use in mould drying results in a BETTER CASTING.



OEHM'S Element drying out a large Propeller Mould in a Marine Engineering Works.

The OEHM'S Patent Heating Element is the simplest and the most efficient apparatus yet devised for producing high temperatures by the conversion of solid fuel to CO_2 gas, possessing pressure and velocity without flame and without smoke.

For Core and Mould drying on the floor, in Pit or Drying Rooms. For Heating Ladles, Shanks, Ingots, etc. For Annealing and all Heat Treatments.

Write for illustrated booklet.

CONSTRUCTED BY

BRITISH DRYING & HEATING Co., Ltd.,

433, ABBEY HOUSE, VICTORIA STREET, LONDON, S.W.1

Telephone : Victoria 2693. *Telegrams : "Britdriet, Sowest, London."*

BRITISH D&H COMPANY LTD

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	58	12	6
Three months ..	59	12	6
Electrolytic	65	5	0
Tough	61	10	0
Best selected ..	62	0	0
Sheets	90	0	0
India	75	0	0
Wire bars	65	10	0
Do. March	65	12	6
Do. April	65	12	6
Ingot bars	65	5	0
H.C. wire rods ..	69	15	0
Off. av. cash, Feb.	59	14	7½
Do., 3 mths. Feb.	60	14	8½
Do., Sttlmnt, Feb.	59	14	1½
Do., Electro, Feb.	66	12	6
Do., B.S., Feb. ..	64	0	0
Aver. spot price copper, Feb. ..	59	14	1½
Do., wire bars, Feb.	66	17	6
Solid drawn tubes		13d.	
Brazed tubes ..		13d.	
Wire		10d.	

BRASS.

Solid drawn tubes ..	12d.
Brazed tubes	13½d.
Rods, drawn	11½d.
Rods, extd. or rlld. ..	7½d.
Sheets to 10 w.g ..	10½d.
Wire	10½d.
Rolled metal	9⅝d.
Yellow metal rods ..	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets ..	8½d.

TIN.

Standard cash ..	292	10	0
Three months ..	282	10	0
English	290	10	0
Bars	295	10	0
Straits	294	5	0
Australian	295	5	0
Eastern	287	10	0
Banca	295	0	0
Off.aver. cash, Feb.	287	4	9
Do., 3 mths., Feb.	280	4	4½
Do., Sttlmt. Feb.	287	3	6
Aver. spot., Feb.	287	3	6

SPELTER.

Ordinary	34	17	6
Remelted	35	7	6
Hard	29	5	0
Electro 99.9 ..	38	0	0
English	35	7	6
India	31	0	0
Zinc dust	44	0	0
Zinc ashes	15	0	0
Off. aver., Feb. ..	36	0	1½
Aver., spot, Feb.	36	1	0¾

LEAD.

Soft foreign ppt.	32	2	6
English	33	10	0
Off. average, Feb.	33	18	0¾
Average spot, Feb.	33	18	0¾

ZINC SHEETS, &c.

Zinc sheets, English	44	0	0
Do. V.M. ex whf.	42	10	0
Rods	48	0	0
Boiler plates ..	42	0	0
Battery plates ..	41	10	0

ANTIMONY.

Special brands, Eng.	99	0	0
Chinese	91	0	0
Crude	61	0	0

QUICKSILVER.

Quicksilver ..	14	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon 25%	9	15	0
45/50%	11	16	0
75%..	21	0	0
Ferro-vanadium— 35/40% 14/- to 15/- lb. va.			
Ferro-molybdenum— 70/75% c. free 6/- lb.			
Ferro-titanium— 23/25% carbonless 1/- lb.			
Ferro-phosphorus, 20/25%, £19 10 0			
Ferro-tungsten— 80/85%,c.fr. 1/9½ to 1/11 lb.			
Tungsten metal powder— 98/99% .. 2/1 to 2/1½ lb.			
Ferro-chrome— 2/4% car. ..	£33	0	0
4/6% car. ..	£22	10	0
6/8% car. ..	£21	15	0
8/10% car. ..	£20	17	6
Ferro-chrome— Max. 2% car.	£39	10	0
Max. 1% car.	£45	10	0
Max.0.70%car.	£56	0	0
70%, carbonless	1/5½ lb.		
Nickel—99%, cubes or pellets £172 to £175			
Cobalt metal—98/99% 10/- to 11/- lb.			
Aluminium 98/99% £118			
Metallic Chromium— 96/98% .. 3/9 lb.			
Ferro-manganese (net)— 76/80%, loose	£15	7	6
76/80%, packed	£16	7	6
76/80%, export	£15	0	0
Metallic manganese— 94/96%, carbonless 2/- lb.			
Per ton unless otherwise stated.			

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten ..	s. 2	d. 6
Finished bars, 18% tungsten ..	3	0

Per lb. net, d/d buyers' works.

Extras—
- Rounds and squares 3 in. and over .. 4d.lb.
- Rounds and squares under ½ in. to ¼ in. 3d. lb.
- Do. under ¼in. to ⅛ in. .. .. 1/- lb.
- Flats, ½in. × ¼in. to under 1 in. × ⅜ in. 3d. lb.
- Do. under ½in. × ¼in. 1/- lb
- Bevels of approved sizes and sections 6d. lb.
- Bars cut to length 10% extra

Scrap from high-speed tool steel—
- Scrap pieces .. .. 3d.
- Turnings and swarf 1d.

Per lb. net, d/s steel makers' work

SCRAP.

South Wales—	£	s.	d.	£	s. d.
Hvy. steel	3	8	6 to	3	12 6
Bundled steel & shrngs.	3	3	6 to	3	7 6
Mixed iron & steel	3	2	6 to	3	5 0
Heavy cast iron	3	3	6 to	3	7 6
Good machinery for foundries	3	7	6 to	3	10 0
Cleveland—					
Heavy steel ..	3	4	0		
Steel turnings ..	2	6	0		
Cast iron borings	2	5	0		
Heavy forge ..	4	5	0		
Bushelled scrap	3	10	0		
Cast-iron scrap	3	5	0		
Lancashire—					
Cast-iron scrap	3	10	to 3	12	6
Heavy wrought	3	10	0		
Steel turnings ..	2	0	0		

London — Merchants' buying prices delivered yard.

Copper (clean)..	51	0	0
Brass (clean) ..	40	0	0
Lead (less usual draft)	30	10	0
Tea lead ..	27	0	0
Zinc	25	0	0
New aluminium cuttings ..	87	0	0
Braziery copper	46	0	0
Gunmetal ..	47	0	0
Hollow pewter	185	0	0
Shaped black pewter ..	140	0	0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—	
Foundry No. 1 ..	72/6
Foundry No. 3 ..	70/-
Foundry No. 4 ..	69/-
Forge No. 4	68/-
Hematite No. 1 ..	78/-
Hematite M/Nos. ..	77/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/6
„ d/d Birm.	94/6
Midlands—	
Staffs common* ..	—
„ No. 4 forge ..	62/6
„ No. 3 foundry	68/-
Shrops. basic	70/-
„ Cold blast, ord.*	185/-
„ „ roll iron* ..	190/-
* d/d Birmingham.	
Northants forge	57/6
„ fdry No. 3 ..	64/6
Derbyshire forge ..	62/6
„ fdry. No. 3 ..	68/-
„ basic	65/-
Scotland—	
Foundry No. 1 ..	81/6
„ No. 3 ..	76/6
Hem. M/Nos.	76/6
Sheffield (d/d district)—	
Derby forge	66/6
„ fdry. No. 3 ..	72/-
Lincs. forge	67/6
„ fdry. No. 3 ..	70/-
E.C. hematite	88/-
W.C. hematite ..	90/-
Lincs. (at furnaces)—	
Forge No. 4	61/6
Foundry No. 3.. ..	64/-
Basic	64/-
Lancashire (d/d eq. Man.)—	
Derby forge	70/-
„ fdry. No. 2 ..	76/-
Northants foundry No. 3	77/3
Dalzell, No. 3	110/-
Summerlee, No. 3 ..	94/-
Glengarnock, No. 3 ..	94/-
Gartsherrie, No. 3 ..	94/-
Monkland No. 3	94/-
Coltness, No. 3	94/-
Shotts, No. 3	94/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars(cr.)	11	5	0 to	12	10	0
Angles				11	10	0
Tees to 3 united ins.				12	0	0
Nut and bolt ..				10	15	0
Hoops	14	0	0 to	15	0	0
Marked bars (Staffs.) f.o.t. ..				14	0	0
Gas strip	12	10	0 to	12	15	0
Bolts and nuts ¾ in. × 4 in. ..				16	15	0
Steel—						
Ship plates	7	7	6 to	7	17	6
Boiler plts. ..				11	10	0
Chequer plts. ..				9	15	0
Angles	£7	0	0 to	7	5	0
Tees	£8	0	0 to	8	5	0
Joists	£7	0	0 to	7	5	0
Rounds and Squares 3 in. to 5½ ins. ..				8	0	0
Rounds under 3 in. to ⅜ in.				7	15	0
Flats, over 5 in. wide and up ..				8	10	0
Flats, 5in. to 1½in.				7	10	0
Rails, heavy ..				8	0	0
Fishplates				12	0	0
Hoops (Staffs.) ..				10	10	0
Black sheets, 24g.				11	5	0
Galv. cor. sheets, 24g.				16	2	6
Galv. fencing wire 8g. plain				14	0	0
Billets,soft	£6	2	6 to	6	5	0
Billets, hard ..				8	2	6
Sheet bars	6	2	6 to	6	5	0
Tin bars d/d	6	2	6 to	6	5	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	3¾
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb. basis.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/- to 1/8½
Wire round— 3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	24.26
No. 2 foundry, Valley	22.26
No. 2 foundry, Birm.	22.00
Basic	21.76
Bessemer	22.76
Malleable	22.26
Grey forge	21.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.80
Beams, etc.	1.90
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.50
Sheets, black, No. 28..	3.25
Sheets, galv., No. 28 ..	4.50
Sheets, blue an'l'd, 9 & 10	2.50
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry ..	32/6 to 37/6
„ furnace ..	20/- to 25/-
Durham & North.	
„ foundry	30/- to 33/-
„ furnace ..	16/-
Other Districts, foundry	30/- to 33/-
„ „ furnace (basis)	11/9

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes, 20×14, box		19/4½
„	28×20, „	38/9
„	20×10, „	29/-
„	18¾×14, „	20/4½
C.W.	20×14, „	17/7½
„	28×20, „	35/3
„	20×10, „	24/4½
„	18¾×14, „	18/4½

Terneplates 28×20, 35/9 per box basis f.o.b.

SWEDISH IRON.

Bars,hammered	£18/10 to £19/0
Rolled Ord.	£16/0/0 to£16/10/0
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12

Pig-iron £6 15 0 to £7 0 0 all f.o.b. Gothenburg.

TUBES AND FITTINGS.
Up to and incl. 6 in.

	Tubes	*Fittings*
Gas	60%	50%
Water	55%	45%
Steam	50%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Feb. 25	59	5	0	dec. 12/6
„ 26	59	2	6	„ 2/6
Mar. 1	58	15	0	„ 7/6
„ 2	58	7	6	„ 7/6
„ 3	58	12	6	inc. 5/–

Electrolytic Copper.

	£	s.	d.	
Feb. 25	66	10	0	No change
„ 26	66	0	0	dec. 10/–
Mar. 1	65	15	0	„ 5/–
„ 2	65	5	0	„ 10/–
„ 3	65	5	0	No change

Standard Tin (Cash).

	£	s.	d.	
Feb. 25	291	0	0	dec. 67/6
„ 26	293	10	0	inc. 50/–
Mar. 1	295	15	0	„ 45/–
„ 2	294	12	6	dec. 22/6
„ 3	292	10	0	„ 42/6

Tin (English ingots).

	£	s.	d.	
Feb. 25	289	10	0	dec. 70/–
„ 26	292	5	0	inc 55/–
Mar. 1	294	10	0	„ 45/–
„ 2	293	10	0	dec. 20/–
„ 3	290	10	0	„ 60/–

Zinc Sheets (English).

	£	s.	d.	
Feb. 25	45	0	0	No change
„ 26	44	0	0	dec. 20/–
Mar. 1	44	0	0	No change
„ 2	44	0	0	„ „
„ 3	44	0	0	„ „

Spelter (ordinary).

	£	s.	d.	
Feb. 25	35	10	0	dec. 5/–
„ 26	35	7	6	„ 2/6
Mar. 1	35	0	0	„ 7/6
„ 2	34	15	0	„ 5/–
„ 3	34	17	6	inc. 2/6

Lead (English).

	£	s.	d.	
Feb. 25	35	0	0	dec. 5/–
„ 26	34	15	0	„ 5/–
Mar. 1	34	5	0	„ 10/–
„ 2	33	10	0	„ 15/–
„ 3	33	10	0	No change

AVERAGE MONTHLY PRICES OF MARKED BARS (SOUTH STAFFS).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0
1898	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	8 0 0	8 0 0	7 11 8
1899	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 10 0	9 0 0	9 0 0	9 10 0	10 0 0	10 0 0	10 0 0	8 3 4
1900	11 0 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 5 10
1901	9 10 0	9 10 0	9 10 0	9 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 16 8
1902	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 7 6
1903	8 5 0	8 5 0	8 5 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 8 9
1904	8 10 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 10
1905	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 10 0	8 1 8
1906	8 10 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	8 10 0	8 10 0	8 10 0	8 10 0	9 0 0	8 15 10
1907	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0
1908	9 0 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 5 10
1909	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0
1910	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0
1911	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0
1912	8 10 0	8 10 0	8 10 0	8 15 0	9 0 0	9 0 0	9 0 0	9 8 0	9 10 0	0 10 0	9 10 0	9 15 0	9 1 6
1913	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	9 10 0	9 10 0	9 4 0	9 0 0	9 0 0	9 13 8
1914	8 12 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	8 14 4
1915	9 0 0	9 0 0	9 3 0	10 2 0	10 15 0	11 10 0	12 0 0	12 0 0	12 0 0	12 7 6	12 10 0	13 10 0	11 5 0
1916	13 10 0	13 10 0	14 13 0	15 0 0	15 0 0	15 0 0	15 0 0	15 10 0	15 10 0	15 0 0	15 10 0	15 0 0	14 18 7
1917	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0
1918	15 12 6	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	17 0 0	17 0 0	17 0 0	16 6 3
1919	18 0 0	18 10 0	20 0 0	20 0 0	23 0 0	23 0 0	23 0 0	24 12 0	25 0 0	25 0 0	25 0 0	25 5 0	22 10 7
1920	26 17 6	27 0 0	28 0 0	30 5 0	30 10 0	33 10 0	33 10 0	33 10 0	33 10 0	33 10 0	33 10 0	33 10 0	31 10 2
1921	31 10 0	30 3 4	27 10 0	27 10 0	27 10 0	24 15 0	21 0 0	20 0 0	20 0 0	17 10 0	17 0 0	16 0 0	23 7 4
1922	16 0 0	14 17 6	14 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 18 1½
1923	13 10 0	13 10 0	13 16 0	14 7 6	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 5 3½
1924	14 10 0	14 10 0	14 10 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	14 17 6	14 17 3½
1925	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 0 0	14 13 4
1926	14 0 0	14 0 0	—	—	—	—	—	—	—	—	—	—	—

WILLIAM JACKS & COMPANY,

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